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THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. II.

No. I.—JANUARY, 1885.

ORIGINAL ARTICLES.

ROBERT ALFRED CLOYNE GODWIN-AUSTEN,

B.A., F.R.S., F.G.S.

AS Time progresses, Geology, although comparatively a modern Science, yet looks back upon its early and honoured leaders, much in the same way as Art regards its "Old Masters." Those pioneers have all left us, and, alas! few even of the distinguished men who belong, as it were, to a second generation now remain. Of these, who in their turn have become veterans in the science, we have recently to deplore the loss of Mr. Godwin-Austen.

The rapid progress of geology has been largely due to the labours and influence of particular individuals; men who, while diligent in the observation of fact, have by a wide grasp of the subject been able to apply their detailed knowledge to the solution of the larger problems of Nature; who by their enthusiasm have kindled a love of science in others, and by their philosophical and suggestive writings have served to direct the inquiries of less gifted students. Among such individuals no one takes higher rank, or was more cordially respected, than Mr. Godwin-Austen, while his genial and courteous manners endeared him to all who had the privilege of his acquaintance.

"Pre-eminently the physical geographer of bygone periods" (to use the words of Murchison) was the subject of our present sketch. And we cannot do better than quote other words of the same authority spoken in 1862, on handing to Mr. Godwin-Austen the Wollaston Medal.

"You have distinguished yourself during a long series of years by your successful inquiries into the former changes of land and water from the Palæozoic age to modern times.

"Persistently keeping that great object in view, you have put forth well-founded hypotheses, based on actual and numerous observations, which have raised the philosophical character of our science. Your sedulous study of the organic remains, as well as the materials of the beds themselves of each formation which you have examined, and your laborious tracings of various lines of dislocation, have all been made subservient to that one great end."

Mr. Godwin-Austen was born in the year 1808, and was the eldest son of the late Sir Henry E. Austen, who died in 1871. In 1833 Mr. Austen married Maria *Elizabeth*, only daughter and heiress of the late General Sir Henry T. Godwin, K.C.B. (who commanded the British Army in Pegu and Burma). He took the additional name of Godwin by Royal licence in 1854.

On March 19th, 1830, Mr. Austen, then of Lincoln's Inn, was elected a Fellow of the Geological Society of London. Sedgwick was then President of the Society, and Lyell, Horner, Buckland, De la Beche, Murchison, Greenough, and Whewell, were among the prominent Members of its Council. Mr. Austen's certificate was signed by the three first-named geologists.

Four years later (November 19, 1834) Mr. Austen read his first paper before the Society, and from that date, until within the last few years, he never ceased to take an active part in its proceedings. In 1841 he was elected a Member of the Council of the Society, and in 1843 and 1844, and again subsequently, he acted as one of the Honorary Secretaries. He has also filled the post of Foreign Secretary and served as Vice-President. Never, however, was he appointed to the Presidential Chair of the Society, although, we believe, he was repeatedly solicited to accept the honour: and certainly no one ever possessed higher qualifications for the office.

Mr. Austen became a Member of the British Association in 1846, and he occupied the Presidential Chair of the Geological Section at Norwich in 1868, and again at Brighton in 1872. He was elected a Fellow of the Royal Society in 1849.

Soon after being elected a Fellow of the Geological Society, Mr. Austen went to reside at Ogwell House, near Newton Abbot. Devonshire thus early became the seat of his field-labours, and his association with De la Beche, whose book entitled "Researches in Theoretical Geology" (published in 1834), has ever been looked on as one of the most philosophical works on the science, no doubt inspired the younger geologist, who became as it were a disciple of that great master.

De la Beche mentions that in the district extending from Dartmouth to Chudleigh, he was principally indebted for the lines on this part of the Geological Survey Map of Devon to Mr. Austen, who had examined the district in great detail.[1] Prof. Phillips, too, mentions the "splendid series of fossils, chiefly from the calcareous strata of the vicinity of Newton Bushel, the fruit of the personal exertions of Mr. Austen during his residence at Ogwell House."[2] These fossils were subsequently presented to the Museum at Jermyn Street.

Mr. Austen's observations are recorded in his paper on the Southeast of Devonshire, in which are embodied the separate communications on the district, made to the Geological Society of London during the years 1834–1840. The map accompanying this paper shows the area investigated and described by the author, and was at the time one of the most detailed geological maps published. In the mean time the observations of Sedgwick and Murchison, aided by the palæontological labours of Lonsdale, had led to the foundation of the Devonian System.[1] This term was not however adopted by Mr. Austen, which he states was "not owing to ignorance of its value as a geological group, but because such a name is at variance with the nomenclature of well-established groups, and because the beds form only one portion of a great primary fossiliferous series for which we already possess materials for subdivisions founded on zoological views, which are preferable to geographical ones."

---

[1] Report on the Geology of Cornwall, Devon, and West Somerset, 1839. p. 69.

[2] Figures and Descriptions of the Palæozoic Fossils of Cornwall, etc., 1841, p. vi.

The details of this complicated region in South Devon are described in the most able manner by Mr. Austen. While noting the connection of the numerous isolated masses of the Great Limestones, he observed that in places they appeared to end abruptly, or to thin away and pass into shaly beds. He concluded that in their structure, as well as in the position, preservation, and grouping of the corals, the calcareous rocks of South Devon afford abundant evidence that their production was analogous to that of modern coral reefs. More recent observations tend to show that many of the isolated masses of limestone are separated by faults; and this is conspicuously the case with the Chudleigh Limestone, which, although regarded by Mr. Austen as belonging to "the slate and calcareous system" of South Devon, was, owing to its apparent intercalation in the Culm-measures, placed with that group on the Geological Survey Map. De la Beche indeed admitted the difficulties in the way of such a grouping.[2] When, however, we recollect the large areas investigated by the older geologists, and that they commenced their labours in regions about which little or nothing was previously known, we cannot too highly estimate the work which they achieved. And in South Devon nothing but a detailed geological survey on the six-inch scale is likely to unravel the many intricate points of structure, and settle beyond question the classification of the various groups of rocks.

It is interesting to read in this early paper, that Mr. Austen noticed the association of human remains, "such as arrow-heads and knives of flint," with other reliquiæ, in clay beneath the stalagmite of Kent's Hole. Equally noteworthy are his suggestions that the "Terminal Curvature" of strata and the Raised Beaches, furnish indications of a much colder period.

Mr. Austen's attention was now directed to the geology of his proper home-county, Surrey; and for many years he resided at Chilworth Manor House, near Guildford.

In 1843 he communicated (in two papers) to the Geological Society some general observations on the geology of Surrey, prefacing them with the remark—needful enough at the time—that the Wealden area was not in its present state a valley of elevation, and moreover, that those movements of the earth's crust, which were thought to be confined to that area, could be traced westwards, and evidently did not commence until after the completion of the lower Tertiary series. These papers are of great interest as indicating the succession of organic remains in the Cretaceous and Neocomian rocks; a succession which in more recent years has been marked out into various "zones." These, and indeed all the papers of Mr. Austen, exhibit his extensive personal observation, combined with the most philosophical deductions, while at the same time they indicate his extensive acquaintance with the writings of others both at home and abroad. No doubt in later years he must have felt the great difficulty, which Lyell and all others have admitted, of keeping pace with the ever-increasing geological literature, that spreads like a deluge over the greater part of the civilized regions of the globe.

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[1] Sedgwick and Murchison, Trans. Geol. Soc. ser. 2, vol v. At p. 651, assistance received from Mr. Austen is acknowledged.

[2] Report, pp. 74, 145.

Mr. Austen was one of the earliest English geologists to adopt the term Neocomian, and, as Professor Judd has remarked, many of his papers expose "the viciousness of the term 'Lower Greensand,' and indicate the necessity for a change."[1] The change is coming no doubt, though its slowness in coming shows how difficult it is to get rid of old and well-known names; and may teach us that they should never be replaced by new terms unless the old ones are absolutely unjust or misleading. It would be impossible in our limited space to do justice to the many important papers contributed by Mr. Austen, and we must refer our readers to the list appended to this article.

We should not, however, omit to notice Mr. Austen's remarks on the Phosphate beds in the neighbourhood of Farnham and Guildford, a subject which had grown into great importance through the observations made on the so-called "Coprolites" of the Eastern Counties by Professor Henslow. Mr. Austen regarded the phosphatic matter as of animal origin, and pointed out that, "where the casts of bivalve shells and ammonites are filled with matter containing phosphate of lime, these forms must have been first inclosed in the sand, that then the proper shelly matter was removed, and finally that the earthy phosphate occupied the place of the hollow. He supposes that the phosphoric acid may have formed part of the coprolitic matter of the time, this matter in part preserved with its original external form, while more frequently it was broken up, and the component portions diffused amid the sand and ooze."[2]

In his paper on the superficial accumulations of the coasts of the English Channel, we have one of the earliest attempts to indicate the sequence of events in the Post-Pliocene period, from the testimony of Raised Beaches, Submerged Forests, Angular detritus, etc. This subject was followed up in a later paper dealing more particularly with the newer deposits of the Sussex Coast. In this latter paper he points out how depressions and elevations have tended, by removing from the action of the sea a more easily disintegrated stratum, or by bringing up a less destructible one, to accelerate or retard the various agents of denudation. One curious illustration of depression is derived from the form of the bottom of the English Channel, which Mr. Godwin-Austen represents as exbiting "lines of troughs and an advancing platform indicative an old coast-line." A more striking proof is derived from the ollusca in the Selsea deposits, which indicate by their habits, allow-water and marginal conditions, that the eastern extension f the Channel at that period may be represented by a line extendg from the coast of Sussex to that of Normandy, and that the emaining portion of what is now the eastern end of the English hannel was in the condition of dry land.[1] Subsequently, the Selsea rratic boulders were drifted into the position they now occupy.

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[1] Geol. Mag. Vol. VII. p. 224.

[2] De la Beche, Address to Geol. Soc. 1849, p. 66.

Mr. Godwin-Austen showed, so early as 1837, that in Devonshire here were terraces of gravel fringing the valleys; and in 1851 and 1855, in correlating these and other Quaternary deposits, he considered that the ancient low-level alluvia of the Thames and Seine valleys, and the old beach and the Elephant-beds of Brighton, were anterior to the Boulder-clay, and he was further of opinion that river- and ice-action had played an important part in producing these valley deposits. He also suggested that the Thames was originally a tributary of the Rhine.[2]

In 1855 Mr. Austen brought before the Geological Society his celebrated paper "On the possible Extension of the Coal-measures beneath the South-eastern part of England"—the most important and suggestive philosophical essay which the Society has received. Judging from facts brought to light in working the Coal-measures of Belgium and the North of France, "and reasoning also on theoretical considerations connected with the extension of the old coal-growth in the west of Europe, Mr. Godwin-Austen concluded that Coal-measures might possibly extend beneath the south-eastern part of England." Illustrating his remarks by a map, "he showed that the Coal-measures which thin out under the Chalk near Thérouanne probably set in again at or near Calais, and are prolonged (beneath the Tertiary strata and the Chalk) in the line of the Thames Valley parallel with the North Downs, and continue thence under the valley of the Kennet, into the Bath and Bristol coal area. He showed, upon well-considered theoretical grounds, that the Coal-measures of a large portion of England, France, and Belgium were once continuous, and that the present coal-fields were merely fragments of a great original deposit, which he inferred had been broken up in two directions previously to the deposition of the Secondary rocks. He showed that the main line of disturbance had a general east and west direction, that part of it formed the great anticlinal of the Ardennes, by which the Belgian coal-field had been tilted up, and brought to the surface, and that the Mendips with the Somerset coal-field were on the same line of strike."[3]

This is but a brief outline of the general conclusions arrived at in the paper, which really deals with the physical geography of the European area at many past epochs.

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[1] We are indebted to the Addresses to the Geological Society of Mr. W. Hopkins, 1852, and of Col. J. E. Portlock, 1857, for notices of these papers.

[2] Prestwich, Phil. Trans. 1864, p. 249; Lyell, Antiquity of Man, ed. 4, pp. 323, 330.

[3] We take these remarks from the Report, by Prof. Prestwich, on the probabilities of finding coal in the South of England, p. 146 (Report Coal Comm. vol. i. 1871).

The remarks on the Palæozoic areas are of especial interest at the present day, for the grouping adopted by Mr. Austen is one which connects the Devonian or Eifelian with the Upper Silurian, and the Old Red Sandstone with the Carboniferous Series. He remarks that "the limits of the lacustrine Old Red Sandstone of the Welsh area are tolerably well defined; they hardly extended as far north as ordinary geological maps now carry that group, inasmuch as the red beds which underlie the coal-measures of Coalbrook Dale belong to the uppermost Ludlow beds, with *Lingula cornea*, etc."

As Dr. A. Geikie observes, "The first attempt to point out the distinction between the typical old Red Sandstone areas and those where rocks of the Devonshire type occurred was made by Mr. Godwin-Austen in his very suggestive memoir . . . . . [which] opened up a new era in the investigation of the history of the Old Red Sandstone."[1]

In a paper read before the British Association in 1870, Mr. Austen suggests that the Devonian system may be a triplex group—partly Upper Silurian, partly Devonian proper (Eifelian). and partly Carboniferous.

In the preface to his "Contributions to the Physical History of the British Isles" (1882), Prof. Hull remarks, "Amongst those to whom I am indebted for light thrown on the internal structure of the British Isles, there is one name which takes unquestioned precedence—that of Mr. R. Godwin-Austen—in whose elaborate essay, published in 1856 by the Geological Society of London, many of the problems since elucidated by experiment were investigated and solved. In reperusing that essay by the light of subsequent discoveries, I have been profoundly impressed by the knowledge of details which its author evinces regarding the geological structure of the region of which he treats, and the masterly manner in which, by the handling of these details, he has enabled us to understand the physical features of Western Europe in past times. I feel persuaded that that essay will ever be considered a masterpiece of geological induction."

The results of the deep borings at Kentish Town, Harwich, and more recently in other places in the South-east of England, have verified the conclusion that Palæozoic rocks would be reached by such borings in this area; but it yet remains to be proved whether productive Coal-measures are also represented.[2]

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[1] Trans. Roy. Soc. Edin. vol xxviii. p. 346.

[2] It is noted in the *Athenæum* (Nov. 29, 1884), that Mr. Austen's views on this subject had been to some extent foreshadowed by De la Beche: the only passage bearing on the subject, which we have come across in De la Beche's writings, is that in Mem. Geol. Survey. vol. i. 1846, p. 214. He says, "From the movement of the older rocks many a mass of Coal-measures may be buried beneath the Oolites and Cretaceous rocks on the east, the remains of a great sheet of these accumulations, connecting the districts we have noticed, with those of Central England and of Belgium, rolled about and partially denuded prior to the deposit of the New Red Sandstone."

In his remarks on the boulder of granite found in the Chalk near Croydon, and which was no doubt transported by floating ice, Mr. Austen attempts to trace out the coast-line during the Cretaceous epoch, in which every other form of sea-bed, from the abyssal to the marginal, must have existed. Remarking on these enquiries Major-General Portlock observes that the author "has appropriated to himself a class of research which is difficult in proportion to its apparent obscurity, but which he is likely by his skill and perseverance to place very high amongst the objects of the philosophical geologist."[1]

Edward Forbes, who died in 1854, left his papers to Mr. Austen. Among these was a Memoir on the Tertiary Fluvio-Marine Formation of the Isle of Wight. This was brought out in 1856, under the editorship of Mr. Austen, who was well qualified for the task, as he had been with Forbes when many of his notes and observations were recorded, and had discussed with him many of the questions that arose. In certain instances Mr. Austen supplied such short notices as were requisite to complete the work, but the memoir was fortunately far advanced by Forbes himself.

Another work, however, which had been undertaken by Forbes, was left by him in a very incomplete state. This work, entitled "The Natural History of the European Seas," was edited and continued by Mr. Austen, and published in 1859. It was a companion volume to Prof. Henfrey's "The Vegetation of Europe"; and Mr. Austen himself had undertaken to write the "Geological History of the European Area"—a work which, however, was never published. The volume on the Natural History of the European Seas had, at the time of Forbes' death, been corrected and printed off, as far as p. 102, and there were proofs (uncorrected) bringing up the work to p. 126; but no further material was forthcoming. Mr. Godwin-Austen, however, who naturally had many difficulties to contend against, laboured hard and successfully at his task; and although it must always be lamented that Forbes did not live to complete this and other works he had planned, yet we may be none the less grateful to Mr. Austen, even if we agree with what he says in reviewing his own portion of the joint volume (in the preface):—"I feel I may be charged with having treated the subject too often from a geological stand-point, and that my share may possibly remind some of the Angel of the sign-painter who had painted Red Lions all his life—and which, in spite of his efforts, looked more like a Lion, than became an Angel, after all."

Mr. Austen contributed to the so-called "Greenough Geological Map," a new edition of which was announced in 1865 by the President of the Geological Society, Mr. W. J. Hamilton. This map, really based on that of William Smith, was brought up to date by utilizing the labours of the Geological Survey, and those of several Fellows of the Geological Society. Mr. Austen contributed greatly to the revision of the S.E. sheet, including the Wealden strata of Kent and Sussex, and the members of the Cretaceous series. He also superintended and laid down from MS. notes, a small portion of France,

[1] Address to Geol. Soc. 1858.

including the Boulonnais. The portion of Ireland, included in the Map, was executed from MS. notes of Mr. Austen, aided by the map of Sir Richard Griffith. Considerable portions of the S.W. of Scotland were also filled in by Mr. Austen.[1]

Many pleasant excursions were made from time to time by Mr. Austen, in company with other Fellows of the Geological Society. Thus in 1849, he accompanied Messrs. Prestwich, Morris, and A. Tylor to the Crag district at Chillesford, in Suffolk; an account of which was afterwards published by Mr. Prestwich, and to whose observations made at this time we date the introduction of that local and debateable deposit known as the "Chillesford Clay."

In 1852 Mr. Austen, together with Edward Forbes, D. Sharpe, Mr. Prestwich and Mr. Tylor, visited Tournay and Mons; and again in 1865, he visited Belgium, in company with Mr. W. J. Hamilton, Mr. Prestwich, Capt. D. Galton, Mr. W. W. Smyth, Mr. Busk and Mr. Gwyn Jeffreys. Mr. Austen's observations on the Belgian Tertiaries were in part made during these excursions.

Mr. Austen was a Member of the Committee formed in 1858 for the purpose of reporting on the Exploration of Brixham Cave; and the Report, which was drawn up in 1872 by Prof. Prestwich, was signed by Mr. Busk, Mr. Austen and Prof. Ramsay.

Mr. Godwin-Austen took but little part in the proceedings of the Geological Society after 1877, when he retired from the Council. He was, however, a Justice of the Peace, and Deputy-Lieutenant for the County of Surrey. He died at Shalford House, near Guildford, on the 25th November, 1884, aged 76.

As remarked in "Nature" (Dec. 4, 1884), "It is some consolation to geologists, who mourn the quenching of one of their luminaries, that his place is taken by a son who, by scientific labours in India and in this country, has proved himself a worthy successor."

HORACE B. WOODWARD.

LIST OF GEOLOGICAL WORKS AND PAPERS OF THE LATE R. A. C. GODWIN-AUSTEN, B.A., F.R.S., F.G.S.

1835.—1. An Account of the Raised Beach, near Hope's Nose, in Devonshire, and other recent Disturbances in that Neighbourhood. Proc. Geol. Soc. vol. ii. pp. 102, 103; and Phil. Mag. vol. vi. pp. 63, 64.

1836.—2. On the part of Devonshire between the Ex and Berry Head, and the Coast and Dartmoor. Proc. Geol Soc. vol. ii. pp. 414, 415.

1838.—3. On the Geology of the South-east of Devonshire. Proc. Geol. Soc. vol. ii. pp. 584-589; Trans. Geol. Soc. ser. 2. vol. vi. pp. 433-489 (1842).[2]

1838.—4. On the Origin of the Limestones in Devonshire. Proc. Geol. Soc. vol. ii. pp. 669, 670.

1839.—5. On the structure of South Devon (or the general relations of the various bands of Slates, Limestones, and Sandstones in South Devon). Proc. Geol. Soc. vol. iii. pp. 123, 124.

1839.—6. Considerations on Geological Evidence and Influences. Rept. Brit. Assoc. for 1838, Trans. of Sections, p. 93.

1840.—7. Note on the Organic Remains of the Limestones and Slates of South Devon. Ibid. 1839, p. 69.

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[1] W. J. Hamilton, Address to Geol. Soc. 1865, p. 33.

[2] In this memoir are given in a condensed form the substance of papers Nos. 1, 2, 3, 4, 5, and 9.

1840.—8. On Orthoceras, Ammonites, and other cognate Genera: and on the position they occupy in the Animal Kingdom. Proc. Geol. Soc. vol. iii. pp. 179, 180.
1840.—9. On the Bone Caves of Devonshire. Proc. Geol. Soc. vol. iii. pp. 286. 287.
1843.—10. On the Geology of the South-east of Surrey. Proc. Geol. Soc. vol. iv. pp. 167-173.
1843.—11. Additional Note on the Geology of the South-east of Surrey. Ibid. pp. 196-198.
1845.—12. On a supposed Aërolite, said to have fallen near Lymington, Hants. Proc. Geol. Soc. vol. iv. p. 584; Quart. Journ. Geol. Soc. vol. i. p. 450. (Brief note only.)
1846.—13. On the Coal Beds of Lower Normandy. Quart. Journ. Geol. Soc. vol. ii. pp. 1-6.
1848.—14. On the Position in the Cretaceous Series of Beds containing Phosphate of Lime. Quart. Journ. Geol. Soc. vol. iv. pp. 257-262.
1850.—15. Notes on the Geology of the Channel Islands. Rept. Brit. Assoc. for 1849, Trans. of Sections, pp. 49-51.
1850.—16. On the Valley of the English Channel. Quart. Journ. Geol. Soc. vol. vi. pp. 69-97.
1850.—17. On the Age and Position of the Fossiliferous Sands and Gravels of Farringdon. Quart. Journ. Geol. Soc. vol. vi. pp. 454-478.
1850.—18. Notes on the Bagshot Sand; General Board of Health Report on the Supply of Water to the Metropolis. 8vo. Lond. Appendix 3, p. 198 (wrongly printed as by W. Austin).
1851.—19. On the Superficial Accumulations of the Coasts of the English Channel, and the Changes they indicate. Quart. Journ. Geol. Soc. vol. vii. pp. 118-136.
1851.—20. On the Gravel-beds of the Valley of the Wey. Quart. Journ. Geol Soc. vol. vii. pp. 278-288.
1851.—21. On Recent Changes of Sea-Level. Report Brit. Assoc. for 1850, Trans. of Sections, pp. 71, 72.
1853.—22. On the Series of Upper Palæozoic Groups in the Boulonnais (with a note by Mr. D. Sharpe). Quart. Journ. Geol. Soc. vol. ix. pp. 231-245, and pp. 245-253.
1855.—23. On Land-Surfaces beneath the Drift-Gravel. Quart. Journ. Geol. Soc. vol. xi. pp. 112-119.
1856.—24. On the possible Extension of the Coal-Measures beneath the South-Eastern part of England. Quart. Journ. Geol. Soc. vol. xii. pp. 38-73.
1857.—25. On the Newer Tertiary Deposits of the Sussex Coast. Quart. Journ. Geol. Soc. vol. xiii. pp. 40-72. Reprinted in Dixon's Geology of Sussex (1878), pp. 24-49.
1858.—26. On a Boulder of Granite found in the "White Chalk" near Croydon; and on the Extraneous Rocks from that Formation. Quart. Journ. Geol. Soc. vol. xiv. pp. 252-266; and Rept. Brit. Assoc. for 1857, Trans. of Sections, p. 62.
1858.—27. On the Conditions which determine the probability of Coal beneath the South-Eastern part of England. Proc. Roy. Inst. vol. ii. p. 511.
1859.—28. Forbes, Edward. The Natural History of the European Seas. Edited and continued by R. Godwin-Austen, 8vo. London.
1860.—29. On some Fossils from the Grey Chalk near Guildford. Quart. Journ. Geol. Soc. vol. xvi. pp. 324.
1850.—30. On the Occurrence of a Mass of Coal in the Chalk of Kent. Quart. Journ. Geol. Soc. vol. xvi. pp. 326-327.
1863.—31. Geological Notes on the locality in Siberia where Fossil Fish and Estheriæ have been found. Quart. Journ. Geol. Soc. vol. xix. pp. 71-73.
1865.—32. On the Classification of the Cretaceous Beds. GEOL. MAG. Vol. II. pp. 199-899.
1866.—33. On the Submerged Forest-Beds of Porlock Bay. Quart. Journ. Geol. Soc. vol. xxii. pp. 1-9.
1866.—34. On the Kainozoic Formations of Belgium. Quart. Journ. Geol. Soc. vol. xxii. pp. 228-254.
1867.—35. Letter, Dr. A. von Koenen on the Belgian Tertiaries, GEOL. MAG. Vol. IV. pp. 565-567.
1868.—36. Address to the Geological Section of the British Association, Norwich,

Aug. 19, 1868. Geol. Mag. Vol. V. pp. 469-480; and Rept. Brit. Assoc. for 1868, Trans. of Sections, pp. 51-58.

1870.—37. The Devonian Group considered Geologically and Geographically. Rept. Brit. Assoc. for 1869, Trans. of Sections, pp. 88-90.

1873.—38. Address to the Geological Section of the British Association, Brighton. Rept. Brit. Assoc. for 1872, Trans. of Sections, pp. 90-96. (Also printed in Nature, August 29th, 1872.)

1877.—39. On the Geological Significance of the Boring at Messrs. Meux's Brewery, London. Geol. Mag. Dec. II. Vol. IV. pp. 474-475.

1877.—40. On some further Evidence as to the Range of the Palæozoic Rocks beneath the South-East of England. Rept. Brit. Assoc. for 1877 (Coloured Geological Map).

II.—Iguanodon Mantelli, Meyer.[1]

By Henry Woodward, LL.D., F.R.S.

(PLATE I.)

In 1822, just sixty-three years ago, Mrs. Mantell found the first tooth of a new and remarkable reptile (afterwards known as *Iguanodon*), imbedded in a mass of coarse conglomerate, which had been brought as 'road-metal' from one of the quarries in the Wealden formation of Tilgate Forest.

This tooth, with others subsequently found in the same rock, was submitted to Baron Cuvier, who pronounced them to belong to a large terrestrial herbivorous reptile hitherto quite unknown.

Various other detached and fragmentary remains were subsequently collected in the Wealden strata, and in 1825 the discovery was communicated by Dr. Mantell to the Royal Society,[2] when the name of *Iguanodon* was proposed for the fossil reptile, from the resemblance which its teeth presented to those of the living *Iguana*, a large vegetable-feeding lizard common in the West Indies and Central America.

In 1834 the first important connected series of bones of *Iguanodon* was discovered by Mr. W. H. Bensted in the "Kentish Rag" quarries of the Lower Greensand formation at Maidstone.

This specimen (which is preserved in the Geological Gallery of the British Museum of Natural History) consists of a large number of the bones of the skeleton of a young individual imbedded in stone in a very confused manner and all more or less flattened and distorted. Amongst them are two long and very slender bones which in the original description are referred to as "two clavicles," and they continued to be so called in Owen's British Fossil Reptiles.[3]

The true nature of these long and slender bones was pointed out by Prof. Huxley in a paper entitled "Further Evidence of the Affinity between the Dinosaurian Reptiles and Birds."[4] They are in fact the ischia, and occupy in Bensted's *Iguanodon* a position near to the ilium, to which they were once united.

Another specimen, embracing the chief part of the vertebral column with some of the bones of the extremities of a supposed young *Igua-*

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[1] "Palæologica," by Hermann von Meyer, 1832, 8vo. (Frankfort).

[2] See Phil. Trans. vol. 115, p. 179.

[3] Pal. Soc. 1851, pp. 111-113, tab. xxxiv.

[4] Quart. Journ Geol. Soc. 1869, vol. xxvi. pp. 12-50.

nodon (since referred to *Hypsilophodon*) from the Wealden of Cowleaze Chine, Isle of Wight,[1] shows the remains of the ilium, with the ischium and rod-like post-pubis attached to it, lying side by side. But the anatomical importance of this specimen was not discovered[2] until Huxley redescribed it in 1869.[3]

In estimating the value of such comparative anatomical studies, we must not, however, omit to take into account the circumstances under which that work was performed, and when we look at the enormous labour accomplished by Sir Richard Owen in describing and figuring the vast number of detached bones and parts of skeletons of new and remarkable Dinosauria in the Palæontographical Society's volumes, we cannot fail to admire his untiring energy and wonderful skill in deciphering so many difficult remains, and are no longer astonished that he fell into some erroneous determinations, but rather marvel that he made so few.

More lately[4] Mr. J. W. Hulke, F.R.S., described a new species of *Iguanodon* (*I. Prestwichii*), from the Kimmeridge Clay, Cumnor Hurst, near Oxford; distinguished from *I. Mantelli* of the Wealden by the shape of the vertebral centra, by fewer than five sacral vertebræ, and by the simpler character of its tooth-serrature.

But interesting and numerous as have been the discoveries of fragmentary remains of *Iguanodon*, in this country, they could only have assisted us to a more or less conjectural notion of the living aspect of this huge Dinosaur, whilst the restoration by Waterhouse Hawkins (1855) was known to be erroneous in several particulars. Two somewhat small Dinosaurs, allied to *Iguanodon*, have, however, been met with in England in a tolerably perfect state. The first of these is from the Lower Lias of Dorset, obtained by the late Mr. Harrison of Charmouth, and is a fairly-complete skeleton of a herbivorous Dinosaur about 12 feet in length, closely allied by its dentition to *Iguanodon*, and described by Sir Richard Owen as *Scelidosaurus Harrisoni*.[5] This reptile was armed with lateral rows of thick bony scutes, and exhibits considerable disparity between the fore- and hind-limbs as well seen in *Iguanodon*, *Compsognathus*, and many other Dinosaurs. There are four functional digits and one rudimentary one in the pes.

The researches of Prof. Huxley and of Mr. J. W. Hulke have also made us acquainted with *Hypsilophodon Foxii*, obtained by the late Rev. W. Fox from the Wealden beds of the Isle of Wight. At first only known from fragmentary remains[6] in 1869, it became possible in 1881 to speak of an almost entire individual about 4 feet in length, preserved in one mass of matrix, besides parts of several others more or less complete. The important remains are figured by the Royal Society in twelve quarto plates, and in the last a complete restoration is given by Mr. Hulke.[1] The animal has four large and powerful digits to the hind-foot[2] and a small rudimentary 5th outer toe; an extremely small manus with four small digits and a 5th rudimentary one. Mr. Hulke thinks that the sharp-pointed and curved ungual phalanges indicate that it was probably arboreal and rock-climbing in its habits. "The sides of the crowns of the teeth are finely serrated and repeat in miniature the lamelliform serration of the crown of *Iguanodon Mantelli*" (*op. cit.*).

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[1] Figured by Owen in Pal. Soc. Foss. Rept. Wealden, tab. I. 1855.

[2] The two ischia and the pubes are marked in the original description as the right tibia and fibula.

[3] Quart. Journ. Geo. Soc. vol. xxvi. pp. 3-12, Pl. ii.

[4] Quart. Journ. Geol. Soc., 1880, vol. xxxvi. pp. 433-456, pl. xviii.-xx.

[5] Pal. Soc. Foss. Rept. Oolitic form. 1861, pl. 2, 4, 5, 6; and 1862, pl. 1-11. Preserved in the British Museum (Nat. Hist.).

[6] See Quart. Journ. Geol. Soc. 1870, vol. xxvi. pp. 3-12, pl. 1 and 2.

Prof. Huxley was the first to draw special attention[3] to one of the most perfect remains known in Europe of a small Jurassic Dinosaur from the Lithographic Stone of Solenhofen, Bavaria, and described some years since by Dr. Andreas Wagner, under the name of *Compsognathus longipes*. "It has a light head with toothed jaws, supported on a very long and slender neck. The ilia are prolonged in front and behind the acetabulum. The pubes (?) seem to have been remarkably long and slender. . . . . . The fore-limb is very small; the hind-limb is disposed as in birds, and is very large, with three digits to the manus and pes. The femur, as in birds, is shorter than the tibia." Notwithstanding its small size—not more than two feet in length—it strikingly resembles the figure of *Iguanodon* (Plate I.), but its proportions are more light and slender, and its dentition shows that *Compsognathus* was carnivorous, whilst *Iguanodon* belongs to the herbivorous type.

Amongst the earlier discoveries of large Dinosaurians in North America must be enumerated, *Hadrosaurus Foulkii*, Leidy, from the Cretaceous beds of New Jersey, an herbivorous animal closely resembling *Iguanodon*, and fully twenty-eight feet in length; and *Lælaps aquilunguis*, Cope, twenty-four feet long, of carnivorous type like *Megalosaurus*. Attempted restorations of both these genera were set up some years since, in the Central Park, New York, by that ingenious enthusiast, B. Waterhouse Hawkins, F.G.S. (see Geol. Mag., 1869, Vol. VI. p. 565), but have been since removed.

To Prof. O. C. Marsh, M.A., F.G.S., of Yale College, Newhaven, belongs the honour of making known perhaps the largest number of American Dinosaurs, some of which as, *e.g.*, *Brontosaurus excelsus*,[4] Marsh, from the Jurassic formation of Colorado, *Diplodocus longus*,[5] Marsh, *Ceratosaurus nasicornis*,[6] Marsh, and *Allosaurus fragilis*,[7] Marsh, have been illustrated in these pages. Altogether more than thirty genera of Dinosauria have been described from North America alone.

It is remarkable, that after more than sixty years, since the first

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[1] See Phil. Trans. Roy. Soc. 1883, vol. 173, part iii. pp. 1035–61 and pl. 71–82.

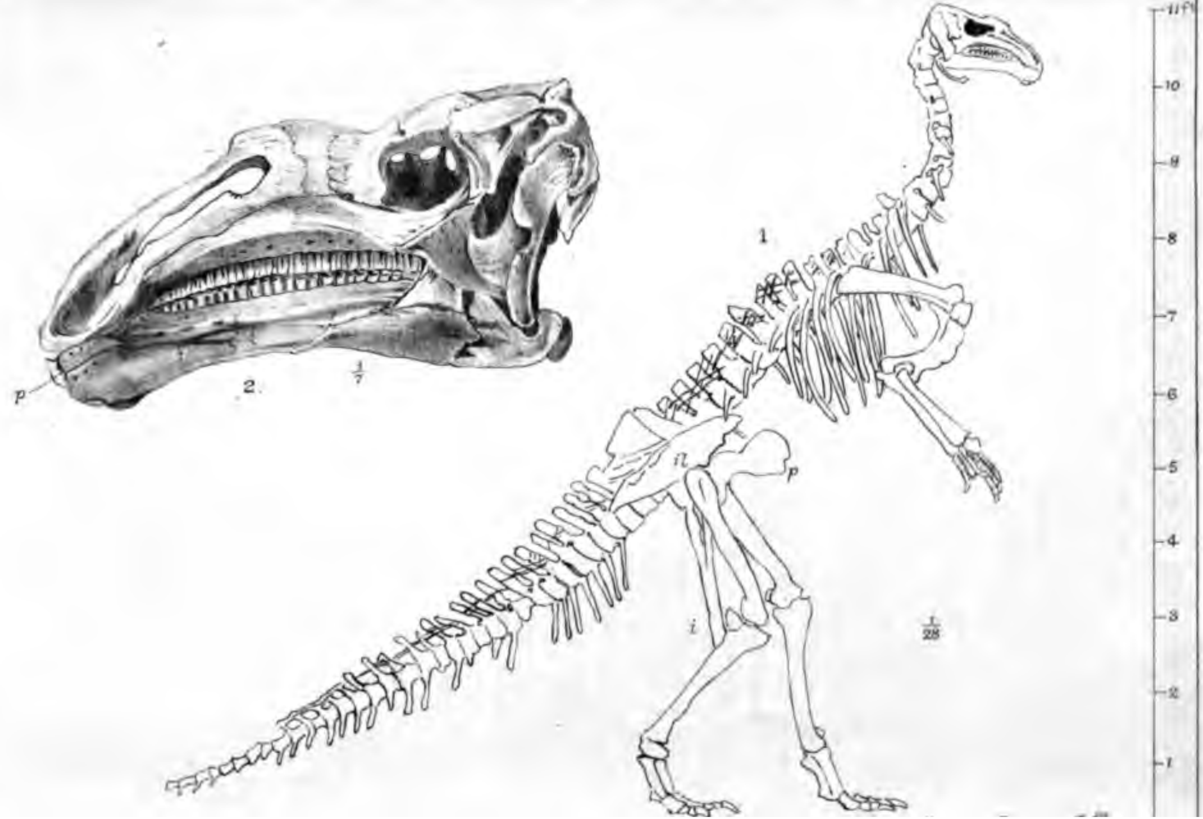
[2] In this point it agrees with *Scelidosaurus Harrisoni*; but that Dinosaur was furnished with rows of bony scutes, whereas *Hypsilophodon* has none. (See the original specimens in the British Museum (Nat. Hist.))

[3] Proceedings of the Royal Institution of Great Britain, Feb. 7, 1868. See also Geol. Mag. 1868, Vol. V. pp. 357–365.

[4] See Geol. Mag. 1883, Dec. II. Vol. X. pp. 385–388, Pl. IX.

[5] *Op. cit.* 1884, Dec. III. Vol. I. pp. 99–107 (10 Woodcuts).

[6] *Op. cit.* 1884, pp. 252-262 (Figs. 1–5). [7] *Op. cit.* 1884, *loc. cit.* (Figs. 6–8).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discovery of *Iguanodon* remains was made in the Wealden—during which time similar reptilia, more or less complete, have been exhumed on the Continent, in England, and in North America, in strata varying in age from the Trias to the Chalk,—numerous perfect specimens should have lately been met with in their original *gisement*, the Wealden formation, from which the first was obtained; not however in Sussex, but in Belgium. Their preservation is due to a very singular circumstance. In the colliery of Bernissart[1]—between Mons and Tournai near the French frontier—the Coal-measures (which are overlain by the Chalk-formation and by thick Quaternary deposits) are fissured in many places by deep valleys or chasms more than 200 metres deep.[2] These must have been formed by denudation and dislocation of the strata in post-Carboniferous times, and were *open gorges* in the old land-surface in the Wealden period.[3] Into this vast abyss were precipitated, by some Cretaceous débacle, twenty-three huge *Iguanodons*, numbers of fish of the genera *Lepidotus*, *Ophiopsis*, and *Microdon*; a Batrachian; several species of Chelonians; and Crocodilians—equally perfect with the Iguanodons;—and numerous ferns of the genus *Lonchopteris*, *Pecopteris*, *Alethopteris*, *Sphenopteris*, *Gleichenites* and *Gleichenia*; agreeing with those described by Dunker from the Wealden of Hanover, and by Mantell from that of the south-east of England.[4]

The ossiferous deposit is separated from the steep walls of coal-shale bounding the chasm by a talus 10 metres thick, composed of *débris* of the coal-formation. The layers are composed of finely laminated blackish clay, interstratified with veins of grey sand and fragments of coal.

The skeletons are imbedded in concretionary masses in the fine clay-sediment with fishes and plants, and indicate a repetition of ossiferous deposits at different levels, more or less widely separated by beds of unfossiliferous clay. The beds themselves are inclined at 70° against the sloping talus, but their inclination diminishes rapidly and is reduced to only 5° at a distance of 12 to 15 metres from the sides of the chasm. The discovery was first made known in 1878, and three years were subsequently spent by M. de Pauw in extracting the great series of fossil-remains from the pit-shaft, the bones being brought up from a depth of 322 metres.[5] It must have been no small inconvenience and loss to the owners of the Sainte-Barbe coal-pit, to allow M. Dupont, the Director of the Brussels Museum and his Assistants, to carry on their researches for so long a period, and bring to bank with care so large and bulky a collection.

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[1] "Sur la decouverte d'ossements d'*Iguanodon*, de poissons, et de vegetaux dans la fosse Sainte-Barbe du charbonnage de Bernissart:" par M. Ed. Dupont, Membre de l'Académie, Directeur du Musée Royal d'Histoire Naturelle de Belgique. (Bulletins de l'Académie Royale des Sci. etc. de Belgique, 2e Serie, Tome 46, Bruxelles, 1878, pp. 387-408.)

[2] 650 feet.

[3] These old land surface-contours are now quite obliterated by deposits of later date which fill up and conceal them, and, save in these deep gorges, the Wealden formation has been completely destroyed and removed by subsequent denudation.

[4] Mantell's Geology of the South-east of England, 8vo. 1833, and Mantell's Wonders of Geology, 8vo. 1838-1858 (7 editions).

[5] Over 1000 feet.

M. Fagès, the Director of the Bernissart Coal-mining Company, deserves the thanks of all scientific men for his liberality in aiding in so generous a manner this important undertaking.

After seven years' labour, two huge entire skeletons adorn the great glass case in the Court-yard of the Museum in Brussels. That of *Iguanodon Bernissartensis* cannot be less than 15 feet in height, and measured along the dorsal line is rather over 30 feet in length, covering nearly 24 feet of ground in its erect position. That of *Iguanodon Mantelli* (see Plate I.) is less in size, and its bones are more slender generally. Its height is rather over 10 feet; its total length, measured along the back, is about 20 feet, and it covers in its erect position (as represented in our Plate) 12 feet of ground.

These magnificent specimens, which I have had the good fortune to visit and study repeatedly, during the past five years of their development, are unrivalled, and their reconstruction reflects the highest credit on M. L. F. De Pauw, the accomplished controller of the workshops in the Royal Museum of Natural History, Brussels, of whose ability as a modeller and reconstructive anatomist I had occasion to speak in high praise, in reference to his reconstruction of the Mammoth's skeleton noticed in 1871 (see GEOL. MAG. Vol. VIII. pp. 193–8, Pl. IV.), also set up in the Royal Museum, Brussels. The task of working out these fossils, originally begun by M. G. A. Boulenger, was subsequently undertaken by M. M. L. Dollo, on M. Boulenger leaving the Brussels Museum to join the Zoological Staff of the British Museum, London, in 1882.

M. Dollo has already published five Memoirs on "*Iguanodon*";[1] one on the Batrachians;[2] one on the Chelonians;[3] and one on the Crocodiles[4] of Bernissart.

A complete figure of *Iguanodon Bernissartensis* was published in 1883, and reproduced in "Nature" (Sept. 6, pp. 439–43) by Prof. H. N. Moseley, F.R.S., who gives an excellent account of the Brussels *Iguanodon.*

In the present year the reconstruction of *Iguanodon Mantelli* has been completed and the figure of the skeleton published. From this our reproduction on Plate I. is derived.

It is hardly possible to over-estimate the importance of the Bernissart discoveries, or the flood of light which they throw upon the structure of the Dinosaurian skeleton. In a subsequent paper we propose to give a notice of some of the more important points which M. Dollo's researches have helped to elucidate. In the meantime we cannot but recall with feelings of the warmest gratitude and admiration those earlier palæontological labourers, who, with exceedingly imperfect materials at their command, succeeded in demonstrating the existence of this great Sub-Class of Animals, which Prof. Huxley has clearly shown occupy a position between Birds and Reptiles, and help us most materially to complete the grand chain by which the Animal Kingdom is linked together.

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[1] See M. L. Dollo, "Première Note sur les Dinosauriens de Bernissart," "Bulletin du Musée Royal d'Histoire Naturelle de Belgique," tome i.—1882. Pl. ix. Fore- and hind-limbs of *Iguanodon Bernissartensis* and *I. Mantelli*. "Deuxième Note," *ibid. op. cit.* Pl. xii. The *sternum*. "Troisième Note," *ibid. op. cit.* tome ii. 1883, Pl. iii. iv. and v. Tibia and fibula and tarso-metartarsal bones compared with Birds and Reptiles. Bones of Pelvis compared. Complete figure of *I. Bernissartensis* ($\frac{1}{25}$th nat. size). "Quatrième Note," *ib. op. cit.* 1883, t. ii. p. 223. "Cinquième Note," *ibid. op. cit.* tome iii. 1884, pp. 129-46, pl. vi. and vii. Crania of Dinosauria compared, and Restoration of *Iguanodon Mantelli.*

[2] "Sur les Batraciens de Bernissart," par M. L. Dollo: *op. cit.* 1884, tome iii. pp. 85-93, pl. iii. *Hylæobatrachus Croyii*, Dollo.

[3] "Première Note sur les Cheloniens de Bernissart," *op. cit. ibid.* pl. i. and ii. pp. 63–79. *Chitracephalus Dumonii*, Dollo, and *Peltochelys Duchastelii*, Dollo.

[4] "Première note sur les Crocodiliens de Bernissart," *op. cit.* tome ii. 1883, pp. 309–338, pl. xii. *Bernissartia Fagesii*, Dollo, and *Goniopholis simus*, Owen.

EXPLANATION OF PLATE I.

Fig. 1. *Iguanodon Mantelli*, Meyer; reproduction on a reduced scale of M. Dollo's beautiful plate, already referred to (Bull. Mus. Roy. d'Hist. Nat. de Belg. 1884, t. iii. pl. vii.) *i*, the ischium: *il.* the ilium: *p*, the pubis.

„ 2. Skull of *I. Mantelli* (seen in profile) ¼th nat. size. *p*, the præsymphisial bone (see observations on this remarkable bone by Mr. J. W. Hulke, F.R.S. (Pres. G. Soc. 1884), in his Anniversary Address, Quart. Journ. Geol. Soc. 1884, vol. xl. pp. 47–51.)

III.—The Cause of Slaty Cleavage: Compression *v.* Shearing.

By Alfred Harker, B.A., F.G.S.,
of St. John's College, and Demonstrator in Petrology in the Woodwardian Museum, Cambridge.

THE received theory of Slaty Cleavage has generally been held to afford a complete explanation of the observed phenomena. The proximate cause of the structure was shown by Dr. Sorby to be a superinduced arrangement of the flat and long-shaped fragments constituting the rock, in virtue of which they tend to lie in, or nearly in, the planes of cleavage; this arrangement being assisted, as Mr. D. Sharpe advocated, by a flattening of those particles themselves. These changes were ascribed to great lateral compression of the rock in the direction perpendicular to the cleavage-planes, together with some expansion along those planes in the line of their dip; and a great mass of evidence was brought forward to support this theory.

In papers recently published in the Geological Magazine (1884, pp. 268, 396, etc.) the Rev. O. Fisher rejects this compression and would substitute *shearing*, *i.e.* a creeping motion such as would distort a cube into an oblique parallelepiped without change of volume (see Fig. 3, p. 399). He indeed admits a certain compression in addition, but it is so slight that for simplicity we may disregard it.

Mr. Fisher contends that the kind of distortion presented by the fossils of cleaved rocks is such as would be produced by a shearing motion, and he seems to imply that these appearances could not be brought about by compression and expansion. But it is easy to see that a shear of given amount is precisely equivalent, so far as distortion is concerned, to a compression of proper amount in a certain direction with a corresponding expansion in a direction perpendicular to it. For the distorting effect of any strain or system of strains can be fully represented by the 'ellipsoid of distortion,' *i.e.* the ellipsoid into which a sphere would be distorted by the strains in question. The section of this ellipsoid by any plane will be an ellipse whose ellipticity will indicate the degree of distortion of an object situated in that plane. Further, the principal diametral plane of the ellipsoid will determine the direction of cleavage. Now the effect of a shear is to distort a sphere of radius b into an ellipsoid of semi-axes a, b, c, and it is evident that the same distortion might equally be brought about by an expansion which would increase the radius of the sphere in one direction from b to a, and a compression at right angles to it reducing the radius in another direction from b to c.

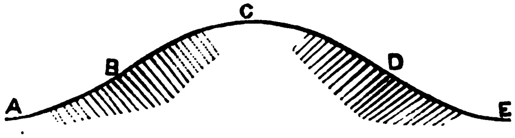

Figure to illustrate the cause of Slaty Cleavage.

It remains to inquire whether shearing can really account for the appearances observed. There being no change of volume, we should have, in the ellipsoid produced by shearing, $ac = b^2$, or in other words the three semi-axes would be in geometrical proportion: whereas in the actual ellipsoid of distortion, as calculated from observations of fossils, a and b are not very unequal, and often sensibly equal, while c is much less than either, thus giving an ellipsoid very like a flat oblate spheroid. This points not to a shear, but to a great compression and a slight expansion, giving rise to a total condensation of volume in the ratio $ac : b^2$.

Mr. Fisher certainly strikes at the weak point of the received theory, when he draws attention to the great *amount* of voluminal condensation which it requires. Thus, if slate of specific gravity 2·64 has been reduced to half its original volume by the process which impressed the cleavage-structure upon it, its former specific gravity must have been only 1·32! Still it seems impossible to escape from the fact of this compression. We have to face, for example, the evidence of the crumpling and folding of resisting gritty bands interbedded with more yielding rocks which show cleavage, as in the now historic cliff-section at Ilfracombe figured by Sorby.

On the other hand, we may notice the great *amount* of shearing demanded by Mr. Fisher's hypothesis in order to produce the degree of distortion commonly observed in the fossils of cleaved rocks. The proper measure of a shear is the relative lateral displacement of two surfaces of shearing divided by the distance between them, or in Mr. Fisher's notation, cot α. It can be readily proved that—

$$\cot \alpha = \frac{a-c}{\sqrt{ac}}.$$

If then $a = 2c$, we have cot $\alpha = {\cdot}7071$ and $\alpha = 54^\circ{\cdot}\,44'$; or if $a = 6c$, cot $\alpha = 2{\cdot}0412$ and $\alpha = 26^\circ{\cdot}\,6'$!

Mr. Fisher has applied his theory to explain the disposition of the cleavage-planes over an extended region, but that was with the supposition, since abandoned, that the cleavage-planes were the actual surfaces of shearing: the amended theory gives much less satisfactory results. Thus, let ϕ be the angle between the cleavage and shearing planes at any given place; then it is easy to prove that

$$\tan\phi = \sqrt{\frac{c}{a}}.$$

This shows that where the shearing and consequent distortion are slight, the angle between the directions of shearing and cleavage will be nearly 45°, and although it is less for a greater amount of shearing, still, even when the shear is so great as to produce a distortion in which $a = 6c$, the angle ϕ is as much as 22°. 12. If we imagine a tract of rocks upheaved to a considerable height and partially settling down with a shearing motion, and if we believe with Mr. Fisher that such shearing is the cause of cleavage in the rocks, it appears from the foregoing formulæ that the result should be similar to that depicted diagrammatically in the figure. At the points *A*, *C*, *E*, there is no shearing and therefore no cleavage; in the neighbourhood of these points there are broad bands of rock with no sensible cleavage-structure. Passing beyond these bands, the planes of ill-developed cleavage have a hade of about 45°: the cleavage becomes gradually more marked and its hade slightly steeper towards the points *B*, *D*, where the shearing is greatest; and near these points the distortion of fossils is greatest and the angle the cleavage-planes make with the vertical is least.

Now I submit that all this is very different from anything recorded as occurring in nature. I have supposed the planes of shearing vertical; if they are inclined outwards as in the figure on p. 275, the discrepancy between theory and observation is still more marked, for the hade of the cleavage-planes from the vertical is then greater.

IV.—WATER SUPPLY FROM THE BAGSHOT AND OTHER STRATA. (No. 2.)

By the Rev. A. IRVING, B.Sc., B.A., F.G.S.,
of Wellington College.

DURING the year 1883 I gave some account, in the pages of this MAGAZINE,[1] of the peculiarities of the water drawn from the Bagshot strata of the London Basin. The most important conclusion drawn in that paper from the evidence adduced was the great difference in the quality of the water according as it is obtained either (*a*) from the bright ferruginous sands of the Upper Bagshots, or (*b*) from the Middle or Lower Bagshot strata, which are all contaminated (more or less) by vegetable matter in various stages of decomposition. So far as the evidence in my possession a year ago seemed to carry me, I felt warranted in making the following generalization: "The whole of the well-water of the district which common human experience pronounces wholesome is obtained from the Upper ferruginous sands." This has been confirmed by additional facts more recently learnt.

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[1] *Vide* GEOL. MAG. 1883, Dec. II. Vol. X. pp. 404-413.

A good instance of the purity of water drawn from the Upper Sands is found in the well at Finchampstead Rectory. This well is about 50 feet deep, and the geological structure of the district shows that the well reaches the water-bearing level of the passage-beds between the Middle and Upper Bagshot strata, the water being held up by the clayey strata which occupy a high horizon in the Middle Bagshot Series.[1] The water from the well is so pure and soft that I can only compare it with water drawn from the crystalline rocks of the Alps above the glaciers. It has only mere traces of mineral matter; it does not become turbid by exposure to the air; and it does not take up iron in solution from pipes or boilers constructed of that metal, and precipitate it afterwards as peroxide, on exposure to the air, as the water from the strata lower down does. This of course we ascribe at once to the absence of vegetable-matter in solution in the water. But now comes an interesting distinction which must be drawn. Though the generalization referred to above has had its truth amply confirmed by later facts, the *converse* of the proposition is only true within certain limits; that is to say, we have no right to assume that *all* the water drawn from the Upper Bagshot Sands is pure and wholesome. Experience shows us that many wells, which penetrate into the Upper Sands only, yield water loaded with vegetable-matter in solution. An example of this is found at my own house. The water is drawn here from a well 17 feet in depth, and I have made quite sure, from the levels of the country as laid down by the Military Ordnance Survey, as well as from actual excavations, that the well does not penetrate any but the Upper Sands, which theoretically, and so far as the evidence given in my former paper seemed to carry us, ought to yield good water. Yet after the well had been disused for a time, the water was *putrid*, and could only be characterized by its smell and other properties as 'bog-water.' A little reflection soon showed that this was due to the *shallowness* of the well combined with the *close proximity of a portion of the ancient forest-lands* of this region; so that within a few yards of the well on two sides there remained a dense coating of peaty matter covering the surface of the ground, clothed with a dense growth of heather, moss, and lichen. By clearing a portion of the ground, and by opening the well permanently to the air, the water has been so far improved as to have lost its offensive smell and taste. It still, however, is so much charged with vegetable-matter in solution, as shown both by chemical tests, and by the amount of iron which it takes up (especially when heavy rains follow a period of drought) from the kitchen-boiler, as to be objectionable for dietetic purposes. Facing the difficulty, I have discovered a process (the details of which are known at present only to myself and the Patent Office) whereby the water can be made as clear, pure, and palatable as water drawn from the crystalline rocks; the water from my well being (after treatment) as good in every way as that from the deeper well at Finchampstead Rectory cited above. Comparing these two typical instances with others of similar nature in the district, we may say generally that it is only *where the old forest-lands of the district have been for some time broken up and cultivated, or where, beginning on high ground, a considerable depth of the Upper Sands* (perhaps 30 feet at least) *is pierced*, that water free from considerable pollution by vegetable-matter in solution can be obtained. It must be recollected that pollution of this nature is quite a different thing, and is easily distinguished, from pollution by sewage, or by manure spread upon an adjoining garden, to which of course all such shallow wells are liable in an exceptional degree in a district where the subsoil is of such a porous character as it is in the district under consideration. I may also add that the same means, by which I have succeeded in removing all vegetable pollution from water drawn from the shallow well quoted above, are available for the purification of the water drawn from the Middle and Lower Bagshot Strata as well as of water collected by gravitation from open moorlands, or drawn off from natural lake-basins.

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[1] See communication by the author to the Geologists' Association, "On the Bagshot Strata of the London Basin," *Proc. Geol. Assoc.* vol. viii. No. 3.

In 1850 the famous engineer Rennie collected a large amount of information on the water-bearing capacity of the Bagshot Sands, and in his Report[1] to the Chairman and Directors of the New River Company he states that "water obtained from siliceous sands, such as those which cover the tract referred to, is proved to be of a quality only equalled in excellence by the water derived from mountain granite rocks, or slate rocks, or other surfaces of the primitive formations." This statement we have seen to be true only to a limited extent: it is true for water obtained from 'siliceous sands' which are free from organic débris, but it is not true for a large portion of the 'siliceous sands' of the Bagshot Series, since these are highly charged with organic matter of vegetable origin. Further on (p. 5) he states that analyses show that the samples of water obtained from the Bagshot Sands are "the purer, the nearer they are collected to the actual rainfall at the surface." This is now easily accounted for, so far as it is true, by the presence of organic matter in the deeper strata, which we may now consider to have been abundantly proved; but the facts which I have described above show that it is only true for those portions of the district where the old forest-lands have been for some time broken up and brought under cultivation. On p. 7 Rennie quotes Mr. Prestwich as an authority for stating that "these sands are not entirely devoid of organic matter." This however is understating the facts, since the evidence adduced in my former paper shows that many of these sands are loaded with it; and since that was written I have been astonished to see the amount of lignite in a fragmentary state which has been brought up from some excavations in the Middle Bagshot Strata. And the lignite is most abundant where the grains of the sand are invariably coated with green, olive-green, and black colloid matter. All references to "green silicates," which were supposed to exist in a granular form in these sands, we may, in the light of our present knowledge, pass by without further notice.

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[1] "Report of Mr. George Rennie on the Supply of Water to be obtained from the District of Bagshot," London, 1850.

In an account of a series of analyses which is appended to Mr. Rennie's Report, and signed William Thomas Brande, much stress is laid upon what is *primâ facie* a serious objection to the use of *soft* water for dietetic purposes. It appears that the experimental evidence goes to show that metallic lead is dissolved from the walls of conduit-pipes much more readily by soft than by hard waters; and it is assumed, without any direct evidence being adduced, that this is due to the mere fact of the 'softness' of the water; that is to say, to its freedom from calcareous salts in solution. The experiments appear however to have been tried with the native unpurified waters of the Bagshot district; we are therefore justified in asking whether the solvent power of these soft waters for lead is due, not to the mere absence of calcareous salts, but to the *presence* of organic matter in solution. The sources of such organic matter in waters drawn by gravitation from the open surface of a country district are obvious enough, as, for example, in the case of the water supplied to the city of Manchester, which is drawn from the open moorlands of North Derbyshire, or in the case of the water furnished to the town of Birmingham, the greater part of which is collected by gravitation into the vast basins which are to be seen in the parish of Shustoke. We must not overlook the fact that where calcareous salts are absent in soft spring or well waters, there is so very often a quantity of vegetable-matter present in solution, owing to the difference in the conditions under which so many water-bearing siliceous sedimentary strata have been deposited, as compared with the conditions under which the calcareous sedimentary deposits were formed, that we may fairly ask the question whether it is not entirely due to the presence of the vegetable acids that 'soft' waters owe their superior corrosive action on metallic lead. An affirmative reply to this question is suggested by the fact that when crenic acid is present in solution as an alkaline salt, it can be precipitated by acetate of lead (Berzelius), the stronger acid going over to the stronger base, and being itself replaced by the weaker acid. Further experimental evidence however is required as to the direct action of the "humus acids" upon metallic lead; here it would be out of place to do more than correct Mr. Brande's inference, by simply following his own mode of testing.[1] Granulated lead was exposed for twenty-four hours in four test-tubes filled respectively with:—

(1) Natural unpurified 'soft' water from the Bagshot Sands;
(2) The same water as in (1) *purified from vegetable pollution*;
(3) Ordinary distilled water;
(4) Distilled water de-oxygenated by boiling for half an hour.

The results observed were that a very *decided turbidity was produced in sample No.* 1, while all the other three retained the perfect clearness of distilled water. It must be added that the sample No. 1 was previously cleared of all *suspended* matter by filtering, so that before the lead was placed in it, this sample was as clear to the eye as the other three were. It is better to reserve further discussion of this subject for another place: so far as the experimental evidence here cited goes, it would appear that Mr. Brande's fallacy (and that of those who have followed him) consisted in overlooking the action of vegetable acids present in solution in the samples which he examined from the Bagshot district.

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[1] pp. 15, 16 (ibid).

"Many of those waters which act upon lead," says Mr. Brande at p. 20, "are also apt to derive contamination from iron, when conducted through pipes of that metal." This is notoriously the case with the Bagshot waters, as I pointed out in my previous paper; and, in the light of later experience, I do not hesitate to affirm that by far the greater portion of the iron contained in the ochreous precipitate, which these natural waters, after passing through iron pipes, deposit on exposure to the air, is taken up in solution by the direct action of the vegetable acids in the water upon the metal of the pipes. This fact, coupled with the generalization of Mr. Brande quoted above, affords indirect but strong support to the theory, that it is only to the frequent presence of the 'humus-acids' in soft natural waters that we can fairly attribute danger arising from the superior corrosive action of 'soft' waters upon lead. This however fails at once as an objection to the use of such waters for dietetic purposes, when we come to know that such vegetable pollution of water may be easily removed before the water is led through metal pipes.

In my former paper I pointed out that we seldom or never see in returns by professional analysts any note as to the *nature* of vegetable pollution of water, though the presence of such matter is frequently indicated. It would be well if in all cases the presence or absence of vegetable pollution were stated, the term 'organic matter' not being sufficiently definite. Under cover of the latter term I have known a writer covertly suggest the befoulment of a certain water obtained from peaty sources with something of a far more serious nature than vegetable matter, when he knew all the time the real facts of the case. It would also be well if regard were had, in all cases of analysis of supposed potable waters, to the *time* which elapses between the collection of a sample and its systematic examination. All statements then as to presence or absence of odour, 'flocculent matter' deposited, etc., would admit of a more definite interpretation than they do unaccompanied by such data; since, however well a bottle may be stopped, it is quite impossible to have filled it with water, without the water absorbing a certain amount of free oxygen from the air, if it is not already fully oxygenated. This remark applies of course in an especial manner to water drawn from deep wells. In illustration of this point I may refer to a case of a well, the water of which is certified by a professional analyst to be "very free from organic pollution"; yet this water fresh from the well has the taste and smell peculiar to vegetable pollution in a high degree, gives an ochreous deposit after being passed through iron pipes, and is found on examination to contain a very considerable quantity of the humus-acids in solution.

Thus far our consideration has been almost entirely confined to the Bagshot strata and the water furnished by them. Pollution of water by vegetable-matter in solution is not, however, confined to these strata, or even to strata of Tertiary age. All the way down the Secondary Series conditions of a similar nature recur at intervals and in different areas: in fact, it is to the later Palæozoic Rocks that we have to go to find in the Coal-measures the maximum of vegetable débris sealed up in the sedimentary strata. Of course in the coal-seams carbonization has proceeded to a greater extent, and the remains of ancient vegetation are presented to us in a more massive form; but between the two extremes there are many degrees, and it seems quite impossible to assign any limits to the time, even in a geological sense, that vegetable débris may remain undestroyed, if it is sealed up hermetically in the strata of the earth's crust, and thus protected from the action of atmospheric oxygen. Several instances of water drawn from various horizons in the Secondary rocks and at the same time highly charged with vegetable acids in solution, have come before my notice within the past year.

1. Some time ago my attention was drawn to three wells in the Wallingford district which draw water from the strata below the Chalk. One of these is the new well at the Lunatic Asylum at Moulsford, the other two are in the town of Wallingford. The water from one of the latter is loaded with vegetable-matter in solution, especially in the form of crenic acid; the other two wells are pretty free from it. A comparison of the sections of the three wells, which I have been able to make through the courtesy of Messrs. Le Grande and Sutcliffe, of Bunhill Fields, who bored the wells, shows that the well which yields water heavily charged with crenic acid, etc., passes through a stratum of dirty dark-green sand, which is altogether wanting in the other two sections. This sand has the character of those impure Bagshot Sands of which I have already said a good deal, and the water drawn from the well is polluted just in the same way as water drawn from the Middle and Lower Bagshot strata is contaminated. No fossils turning up, it is not easy to determine the exact horizon from which the water of these three wells is drawn. The section of the well which yields impure water is as follows:—

		ft.	in.
1. Sand and gravel (river alluvium) 2. Clay, light blue and loamy 3. Hard light grey rock (Upper Greensand)	about	22	0
4. Stiff grey clay (Gault)		20	0
5. *Dark green sand*		0	6
6. Hard rock (sandstone)		2	0
	Total	44	6

Comparing this with the description given by Prof. Phillips[1] of a section at Culham not very many miles distant, it seems extremely likely that the 'hard rock' or sandstone pierced by this well for two feet at the bottom is none other than the sandy cap of the Kimmeridge Clay, and that the Lower Greensand is represented in the well-section at Wallingford, as it is in the Culham section, by a few inches only of dirty green sand. It is possible that the well in question has tapped an underground reservoir consisting of an ancient lagoon-deposit or silted-up lake; and if this be the case, the pollution of the water with vegetable-matter is accounted for. The absence of the whole of the Portland and Purbeck series, and the extreme attenuation of the Lower Greensand, gives countenance to such a hypothesis.

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[1] Vide *Geology of Oxford and the Valley of the Thames*, p. 427.

2. Going further north, to the little town of Brackley in Northamptonshire, we meet with phenomena somewhat similar to those just described. Here too there is a considerable break in the geological series, as the Great Oolite rests generally in the district upon the ferruginous sands which cap the Upper Lias Clays. That the rich deposit of ironstone, known as the Northampton Sands, owes in part its existence to the agency of vegetable acids, I have little doubt;[1] but the fact which bears immediately upon our present subject is the occurrence, in the section of the well at the Brackley Waterworks, of twelve feet of "running sand," taking the place of the more highly ferruginous deposits which are commonly met with at this horizon. Nearly one-half (the lower half) of this running sand is of the same character as the dirty green and grey sands of the Bagshot series. A copious supply of water was obtained here, but it was found to be so objectionable as to quality, that it was rejected for the use of the town, and the well was continued down another 100 feet, until it penetrated the more calcareous rocks of the Middle Lias. The water obtained from the *sand* at a depth of 63 to 75 feet (the whole depth of the well being now 175 feet) was described to me as being 'brackish'; and there seems little room for doubt that a careful examination of it would have shown it to be polluted with vegetable-matter in solution. Even the water pumped up from the Middle Lias is not quite free from this, and being at the same time slightly charged with bi-carbonate of lime, it deposits a curious amorphous precipitate resembling kaolin in appearance, inside the engine-boiler. This deposit is found to contain some carbonate of lime, but is mainly composed of silicate of alumina, the latter being in all probability precipitated by the decomposition, during the process of digestion which goes on within the boiler, of double soluble salts, formed by the combination of silica and the 'humus-acids' with alumina as a base.[2]

Looking at the facts of the two cases now cited, we find a certain resemblance between them. In both cases there is a break in the normal geological succession of the strata, and this of course implies more or less of erosion of the lower series at both places. Under such conditions it is extremely likely that in hollows formed by such erosion there should have been accumulations of such coarse sandy materials as are characteristic of shallow waters, and that along with such materials much vegetable débris should have been brought in some instances from the adjacent land-surfaces, or accumulated from the decay of aquatic and marsh plants in the well-known process by which lakes are often filled up with sandy and peaty matter. The twelve feet of sand in the section at Brackley may represent the 'Midford Sands,' the 'Cephalopoda Bed' of the Cotswold country being absent in this part of England. Whatever their history, it is their petrological character which concerns us here.

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[1] Comp. my paper, *On the Coloration of some Sands, etc.*, in the Report of the British Association, 1883.

[2] I am indebted to the courtesy of Sir George Bannerman, Bart., in bringing the facts connected with the Brackley well under my notice.

3. At Evenley, about a mile from Brackley, there is a well thirty feet deep, which receives its water from the strata of the Great Oolite, and this water is contaminated by vegetable-matter in solution. This is proved, not only by the direct precipitation of crenic acid from the water in considerable quantity, according to the method given (from Berzelius) in Watts' *Dictionary of Chemistry*, but also by the presence of a high percentage of albumenoid ammonia, while there is the merest trace of free ammonia, and the amount of chlorine is very small, not more than 1·3 grs. per gallon.[1] It should be added that the water of this well was examined, when it had an unusually strong smell betokening vegetable pollution, soon after the heavy rains, which followed upon the long period of drought experienced in the early part of the summer of last year. In this case too the water has been found capable of purification by the process, to which I have referred above. This well probably penetrates a dirty bed, such as was passed through in the Brackley well at a depth of from thirty-one to forty-one feet, interbedded with the limestones and marls of the Great Oolite. One fact in connexion with the water of this well puzzled me for a time: the water, when heated and drawn from the kitchen-boiler, was not discoloured in the slightest degree by iron, as is the case with soft water contaminated by vegetable-matter in solution. This was ultimately explained by the fact that the calcareous hardness of the water has produced a lining of carbonate of lime, owing to the decomposition by heat of the bicarbonate, which the water brings in solution from the Oolitic strata. The failure of the vegetable acids in this case to take up iron results therefore from the fact of non-contact between the water and the iron. The fact throws additional light upon the theory of Mr. Brande and others, on which some remarks have been made above.

In the light of our present knowledge we may hazard a provisional generalization, which will lead us to look for vegetable contamination in many cases of water drawn from such levels as are marked by any considerable break in the normal succession of the strata; such, for example, as that which occurs so often all down through the Vale of Wardour, and down to the coast of Dorsetshire, the Cretaceous series resting unconformably upon various members of the Mesozoic strata, down even to the Trias.

We must return for a further brief consideration of the Bagshot strata. In the pursuance of my observation upon these strata in East Berkshire, the conviction has gradually grown up in my own mind, that the relative distribution of the different members of that series is not accurately delineated on the map (now somewhat antiquated) of the Survey. I have not yet completed the evidence so far as to warrant me in bringing it forward in a more formal manner; but, in brief, the conclusion at which I have provisionally arrived is that a far greater horizontal distribution of the *Upper* Bagshot Sands exists, than is represented on the map. The passage-beds from the Middle to the Upper Bagshot strata have certain physical characters recognizable by those who have made a special study of the district; and by these means one can make out pretty well an identity, as to horizon, of the sands, etc., exposed resting on the eroded surface of the London Clay, at Wokingham in one direction and at Aldershot in the other, with the strata exposed in the railway-cuttings near Wellington College Station.[1] The continuity of the Upper Sands had been greatly destroyed by denudation; but that is no proof that there was not once a continuous deposit of them, covering up completely the Middle and Lower series, overlapping these, and extending itself upon the eroded surfaces of the London Clay, which must have flanked the great estuary in which these Upper Sands were accumulated. All the physical characters point to the deposition of the Middle and Lower series having taken place under conditions which prevailed in the marshes and lagoons of an extensive *delta;* while the absence of all indications of such conditions in the Upper Sands, and the presence in them in places of great numbers of ferruginous casts of marine shells, seems to record the fact (taking the negative evidence with the positive) that the period represented by the Upper Sands was marked by a gradual subsidence, which led to a much greater extension of the area of deposition (in the London Basin) and an encroachment of marine waters. We seem justified then in regarding the Upper Bagshot Sands as a true *estuarine* deposit; and it will be seen at once, that this fact is of considerable practical importance as bearing upon water-supply, and should be borne in mind in the selection of sites for new wells, and in determining the depth to which such wells should be dug, in the Bagshot District.

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[1] Comp. Wanklyn's *Water Analysis*, 5th ed. 1879, p. 49.

V.—Gulf Stream Deposits.

By T. Mellard Reade, F.G.S.

THE interesting and important results of the dredgings by the U. S. Steamer Albatross[2] between July and September 1884, should not be allowed to pass without notice by geologists.

In N. lat. 39° 46′ 30″, W. long. 70° 14′ 45″, large blocks of sandy clay, some weighing 100 lbs., were brought up. "It was estimated about a ton was brought up." The depth was 1060 fathoms.

In 1168 fathoms N. lat. 38° 27′, W. long. 73° 02′, the dredge brought up "a large quantity of masses of hard but sticky greenish-blue clay, some masses varying to yellowish and buff colours."

These depths of the sea, which are both over a mile, and from 100 to 120 miles from the land, ought according to the Challenger experiences to be occupied by "Globigerina Ooze," but so far from the theory of distribution of oceanic deposits by depth holding good in the region of the Gulf Stream, it is stated by Prof. Verrill "in other localities in 1000 to 1600 fathoms, the bottom is covered with, or largely composed of, hard, very irregular flattened crust-like concretions of clay and iron oxide."

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[1] Compare *Proc. Geol. Assoc., loc. cit.*

[2] Marine Fauna and Deep-sea Deposits off the Southern Coast of New England, by A. E. Verrill.—Amer. Journ. of Science, November, 1884.

In another station "a large number of pebbles and small rounded boulders of granite, porphyry, etc.," occurred in a depth of 2021 fathoms.

"In all our ten localities between 2000 and 3000 fathoms the bottom has been 'Globigerina Ooze.' We have never met with the 'red clay' which ought to occur at such depths according to the observations made in the cruise of the Challenger."

It is rather refreshing, after all, to find that Nature works in the sea as elsewhere, in varied ways, and that it is not as was generally supposed that monotonous waste of "ooze" and "red clay" mathematically arranged according to depth.

The Challenger work, while of enormous value. has also been in my opinion the source of many misconceptions and generalizations really unwarranted by the extent and nature of the information gathered.

Before we can accept the dictum that all sedimentary deposits arising from the settlement of matter in suspension are confined to a zone not reaching over 200 miles from the land, we must have many more dredgings around the continental coasts. In this excellent work of the Albatross we have, I think, evidence that ocean currents such, as the Gulf Stream, carry with them matter in suspension—and it is unreasonable to suppose that this must necessarily be all deposited within a certain limited distance from the land—its deposition being really determined by the velocity of the current. I have recently in my Presidential Address to the Liverpool Geological Society given my reasons for thinking that the fine argillaceous matter which is found among all the deep-sea oozes is really a mechanical deposit from the ocean waters.

It would seem to me that while every new deep-sea dredging to some extent modifies previous views, it is hardly wise to attempt to draw for all time such rigid lines of demarkation between the land and the ocean as some have lately tried to do.

NOTICES OF MEMOIRS.

I.—MAPOTECA GEOLOGICA AMERICANA.

A Catalogue of Geological Maps of North and South America, in geographic and chronologic order, has just been published by the United States Geological Survey (1884).[1] The work has been prepared by Messrs. Jules Marcou and J. B. Marcou.

The earliest map noted is one dated 1752, by J. E. Guettard, ntitled "Carte minéralogique où l'on voit la nature des terrains du anada et de la Louisiane."

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[1] Bulletin of the United States Geological Survey, No. 7.

A geological map of a part of Massachusetts on Connecticut River, y E. Hitchcock (1817), is next in point of date; after which the umber rapidly increases, so that no less than 924 maps are numerated in this Catalogue, which includes all maps published to he end of 1881.

In an introduction the authors give some account of the history of eological maps, and state that "The first geological map is due to he Abbé L. Coulon, Paris, 1664. It appeared in a little volume ntitled, "Les Rivières de France," a very rare work, of which but ery few copies exist in the libraries of Paris."

I.—NOTICE OF A GEOLOGICAL MAP OF MONTE SOMMA AND VESUVIUS.[1]

By H. J. JOHNSTON-LAVIS, F.G.S.

VESUVIUS, using this term for the whole volcanic pile, is of all known volcanoes that one which has been most studied and ritten about, its phenomena more investigated than any of its ivals, and although its early history is not so complete as that of its ellows, Etna and Stromboli, yet its eruptions during the Christian Era are so intimately connected with the ill-fated cities of Pompeii, etc., and thus with archæology, that this alone is sufficient to make it most prominent.

But beyond this, its geological structure is so varied, its products so numerous, its past and present historic activity permitting the comparative study of these to be carried on, together with its convenient size and accessibility, led the author some years since to conceive the idea of minutely investigating its phenomena and structure, which it is his intention to publish in the form of a monograph and a geological map.

The two out of six sheets forming the splendid map constructed in 1876 by the students of the Italian School of Military Topography, on the large scale of 1 : 10,000 have been coloured in seven different tints, indicating the various products of different eruptive periods,[2] with indications of dykes, of lateral craterets, of springs simple, or thermo-mineral, blowing caverns, buried antiquities (of geological interest), etc. The work has now extended over four summers, and the examination of about half, including the most complicated part of the mountain, has been completed, and the author hopes that if he is able to continue the work during the present and next summer, to finish it by the autumn of 1885. This long time occupied in the work is dependent on various causes. 1st. The great intricacy of the geology. 2nd. The thick vegetation requiring very numerous traverses. 3rd. The author, for professional reasons, being only able to devote the summer months to the work; the hot Neapolitan sun of this season is so exhausting that not more than four field days a week are possible, and even then at a considerable sacrifice of health. In the two sheets exhibited are a few blanks that require further study, or have been left for various reasons. The work on the other four sheets is of so scattered a nature at present that it was not thought advisable to exhibit them till in a more complete state.

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[1] Brit. Assoc. Reports (Sec. C. Geology), Montreal, 1884.

[2] See Memoir by the author in Quart. Journ. Geol. Soc. January, 1884.

Besides the actual mapping, a large amount of notes of a descriptive character have been collected, and all the important features and sections photographed on a large scale. Specimens of the various lavas, ejected blocks, tufas, pumices, etc., have been carefully selected as the work went on, so that the author has now in his possession by far the most complete geological collection from the mountain yet extant, and which are open to the study of any one who should care to investigate them.

REVIEWS.

I.—THE AZOIC SYSTEM AND ITS PROPOSED SUBDIVISIONS. By J. D. WHITNEY and M. E. WADSWORTH. (Bulletin of the Museum of Comparative Zoology, at Harvard College, Geological Series, Vol. I.)

THOSE who have read Dr. Sterry Hunt's "Special Report on the Trap Dykes and Azoic Rocks of South-eastern Pennsylvania," which is in fact a *résumé* of the evidence on Dr. Hunt's side of the Archæan controversy, will be interested in the book before us. Prof. Whitney and Dr. Wadsworth renounce Dr. Sterry Hunt and all his works. They present the case against him with fullness and force. They regard most of his chief conclusions as either unsubstantial dreams or pernicious heresies. They are, in truth, as thoroughgoing in their condemnation of the modern views on Archæan Geology as Dr. Hunt is in their support. Dr. Hunt's boldness in creating hypotheses seems to have driven our authors into the extreme of scientific scepticism. This reaction is not altogether unnatural. Those who desire to take an impartial view of the Archæan controversy will anticipate that, from the strong antagonism of the disputants, there may arise a searching inquiry into the grounds on which their conclusions are based.

Dr. Hunt claims that he and his co-workers have established the existence of seven distinct terranes amongst the rocks which underlie the Cambrian. These, taken in ascending order, are as follows:—

I. LAURENTIAN.
II. NORIAN or Labradorian.
III. ARVONIAN.
IV. HURONIAN; the altered Quebec group of Logan.
V. MONTALBAN or Mica-schist series.
VI. TACONIAN; the Lower Taconic of Emmons.
VII. KEWEENIAN; the Copper-bearing series of Lake Superior. Dr. Hunt is not certain that this group may not be roughly contemporaneous with the Taconian.

This list is an imposing one, and, if it represents the facts of nature, the range of Archæan time may well compare with that of the entire Palæozoic series, and the study of these ancient rocks becomes one of the first importance.

Our authors deal very trenchantly with Dr. Hunt's conclusions. e Norian, Arvonian, and part of the Huronian are relegated to the tegory of intrusive igneous rocks. The rest of the Huronian is garded as a variety of things, but usually as altered "Silurian." For e Keweenian a Potsdam age is positively claimed. The Montalban d Taconian are either a part of the (so-called) Laurentian or etamorphosed Palæozoic rock. Nothing is left, but a confused ass of strata, to which the general name of "Azoic" is applied. our authors are right, the Archæan regions are almost a *terra cognita.* Few true results have been obtained, because false ethods of work have been adopted.

One of the fallacies which, in the view of Messrs. Whitney and adsworth, has misled Logan and his followers, is the assumption hat the so-called metamorphic rocks were deposited as aqueous sediments, and that the present foliation corresponds with the original edding. Our authors do well to express this caution. Igneous ocks, which have by pressure acquired a foliated structure, have ometimes been described as metamorphic, and identified as Archæan formations; but modern workers are becoming aware of the danger of deception, and a good field geologist will rarely be led astray. Part of the old work will probably require revision, and some of the "Archæan" masses may fall back into their old state of "granite" or "greenstone." But we apprehend that the American and Canadian Archæan geologists will hardly admit that the existence of pressure foliation in igneous rocks is a fatal hindrance to the success of their work.

Our authors also wisely call attention to the possibility of error in using the test of included fragments. They insist upon the fact—familiar enough to geologists—that in volcanic formations, included fragments may be the result of contemporaneous denudation. They assert that the so-called Keweenian (Keweenawan) system owes its existence to the blunder of supposing that conglomerates in Potsdam rocks prove the superior antiquity of the masses from which the included pebbles were derived. Other errors of the same kind have, in the view of our authors, seriously invalidated many of the conclusions of Hunt and his co-workers. On these criticisms, with the evidence furnished in the book before us, we can say nothing. Each case must be tested on its own merits, and an opinion can only be formed on full lithological descriptions, confirmed by the microscope.

It was to be expected that our authors would make a point of Dr. Hunt's frequent change of opinion. But it is only fair to Dr. Hunt to state that these changes have usually been in one direction. Territory after territory has been absorbed into the Archæan empire, but we do not remember any case in which the conqueror has restored any of his annexations.

British geologists will be rather surprised to learn that even Sir Roderick Murchison betrayed a "want of tenacity of opinion" on the Archæan question. Our authors, however, accuse him (p. 521) of this weakness, simply because he recognized the Laurentian and

Huronian systems of the Canadian geologists, and admitted that *Eozoon* was organic. This critical narrowness is, in the same page, accompanied by a bold inaccuracy, by which a hesitating opinion of Murchison is converted into a contradiction.

If so conservative a geologist, as Murchison was in his later years, comes under the censure of Prof. Whitney and Dr. Wadsworth, we are not astonished to read in these pages that "no reliance is to be placed in Logan's much vaunted work and sections, beyond the question of surface distribution," and that Dana, James Hall, and, indeed, the great bulk of American and Canadian geologists, became involved in confusion and error when they got among the crystalline rocks.

Our authors bring into prominence a very serious discrepancy amongst the American students of the old rocks. Dr. Sterry Hunt definitely places the Norian below the Huronian, and the Huronian below the Montalban. But Prof. C. H. Hitchcock, as quoted by our authors, makes both the Norian (pp. 390, 392) and the Huronian (pp. 393, 461) to be younger than the Montalban. In the British area, Dr. Hunt has identified the Huronian and the Montalban ; but his older series is less crystalline than the younger, and the present writer hopes soon to publish stratigraphical evidence which will tend to reverse the order which Dr. Hunt has announced, so far as these islands are concerned. This is a matter which requires some explanation from American geologists.

Our authors, "in view of the contradictions and confusion of ideas thus shown to exist among the most eminent geologists in reference to the nomenclature of the oldest crystalline rocks," offer "a contribution" towards a "more definite understanding" of the subject. The first part of this "contribution" is a defence of the term "Azoic." It is, perhaps, not unnatural that Messrs. Whitney and Wadsworth should uphold the use of a term which was originally proposed by Messrs. Foster and Whitney. Our authors maintain that the usual evidence for the existence of organic remains in the rocks below the Cambrian is insufficient. *Eozoon*, they contend, is a mineral structure, and limestones may be formed without the agency of animals or plants. Apatite, also, and the forms of carbon, graphite and the diamond, occur as the original constituents of rocks. All this may be consistently admitted without accepting the term "Azoic," which implies, not that no traces of life have been found, but that none occur, in the old rocks. This argument appears to have affected Dr. Sterry Hunt in a very singular manner. In his work on South-eastern Pennsylvania, in 1878, he uses the term "Azoic"; but, since the publication of the book before us, he has announced[1] the adoption of the word "Hypozoic." This is like converting a sinner *to* the error of his way.

A second "contribution" towards a settlement is the statement that "no fact is better or more generally recognized than this: that geological time can only be kept by the aid of palæontology" (p. 552), an assertion which will come to most British geologists as a revelation of the unknown. If this "fact" be admitted, of course there is an end of the matter. If time can be kept only by a gold watch, it is useless to purchase a silver one. But some of us can remember that, long before Archæan geology became a prominent study, attempts were made to keep geological time without the aid of fossils. The Harlech grits and the Tarannon shales, for example, were assigned their approximate place without a particle of fossil evidence; and, even if the past conclusions of Archæan geologists should prove to be altogether fallacious, it seems scarcely scientific to assume that only one test of age is applicable, and on this ground to prohibit efforts to make out a succession in the Pre-Cambrian rocks.

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[1] Geol. Mag. Nov. 1884, p. 506.

Our authors state (p. 560) that "only lithological principles are used in making these (Dr. Hunt's) divisions, and every fact pertaining to the origin and relations of these rocks is ignored." If this is so, Dr. Hunt must be very wild indeed. But having thrice read his "Trap Dykes and Azoic Rocks" with great care, the present reviewer must in justice affirm that a large proportion of that elaborate work is occupied in attempts (successful or otherwise) to explain "the origin and relations" of the rocks in question. The "contribution" which our authors offer under this head is, of course, that "lithological principles" should *not* be exclusively employed, a piece of advice which will be unanimously, if not thankfully, accepted.

This paper will fitly close with our authors' last "contribution" to a settlement. Side by side with Dr. Hunt's "Chronological arrangement of the Crystalline Rocks," based, they say, exclusively upon "lithological principles," is presented a new classification of their own, constructed upon the same model. It is as follows:—

LAURENTIAN	Granites, Gneisses, and Syenites.
SIDERIAN	Magnetite, Hematite, Menaccanite.
OPHIAN	Peridotites, including Serpentines.
NORIAN	Gabbros, coarse Diabases and Diorites.
ARVONIAN	Felsite, Quartz Porphyry, Petrosilex, Jaspilite.
PORPHYRIAN	Porphyrites.
HURONIAN	Diorites, Diabases, Melaphyres, Chlorite Schists.
MONTALBAN	Mica schists.
CRYSTALLIAN	Quartzites, Quartz schists.
TACONIAN	Limestones.
GLACIAN	Conglomerates.
PELODIAN	Argillites.

It is, of course, impossible to exhaustively criticize this book within the limits of a short paper. All that has been attempted is to emphasize some wise cautions which Archæan geologists have sometimes neglected; to point out wherein the authors have misstated or misunderstood the views of their opponents, and to show that their own contributions towards a settlement add little or nothing to the controversy.

In conclusion, it may be suggested that wholesale charges of ignorance and incompetence are not arguments, and do not tend to mitigate controversial acerbity.

C. CALLAWAY.

II.—A GUIDE TO THE MINERAL GALLERY OF THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, SOUTH KENSINGTON. WITH AN INTRODUCTION TO THE STUDY OF MINERALS. (By L. FLETCHER, M.A., F.G.S., etc.) Printed by Order of the Trustees. 1884.

THE removal of the Natural History Collections of the British Museum from their old home in Bloomsbury to the larger buildings at South Kensington has permitted, not only of their more complete exhibition, but also of their being arranged in such a way as to be of far greater value for educational purposes. The curators of the several divisions of the Museum have hastened to take advantage of the opportunities now offered to them. The Index Museum, the Osteological Collection, and the beautiful illustrations of the nidification of birds, all bear witness to the desire on the part of the director and keepers to make the Museum something more than a mere show: and every gallery as it is thrown open to the public, after the heavy task of re-arrangement is completed, exhibits to a greater or less degree evidence of a determination to consult the wants of students while those of the general public are not lost sight of.

We have much pleasure in calling attention to the excellent little Guide to the Mineral Gallery, in which the present arrangement and the reasons for adopting it are explained and illustrated with admirable clearness by Mr. Fletcher, the Keeper of the Collection.

Mr. Fletcher first tells us the history of this now famous collection of minerals—one which he speaks of with just pride as of "perhaps unrivalled excellence as well in its general completeness as in the perfection of individual specimens." He shows how around the nucleus of a few agates and other worked specimens in Sir Hans Sloane's museum, the collections obtained by purchase or bequest were gradually gathered. Among the chief collections of minerals which were thus acquired by the British Museum were those of Cracherode, Greville, George IV., Heuland, Lady Aylesford, and Dr. Bright; but most important of all, on account of the care with which they were made, those of Allan and Greg and of Kokscharow. Mr. Fletcher bears testimony to the judgment with which Mr. Story-Maskelyne, his predecessor in the office of Keeper during nearly a quarter of a century, advised the Trustees in the purchase of the specimens which were required to make the collection complete in its various departments.

As the author of the Guide points out, it is very difficult to make the grounds of mineralogical classification clear to persons who have not made a special study of the subject. Those who walk through the galleries will be struck by the fact that minerals of very similar appearance are placed far apart from one another, while others which differ in colour and general aspect to a most surprising extent are grouped together under the same name. To make the reasons of these apparent anomalies clear to the general public is the object the "Introduction to the Study of Minerals," which occupies some forty-four pages of this little guide.

In writing this charming little sketch, Mr. Fletcher has, very iciously we think, adopted the historical method. The difficulties ich confront the individual in his study of minerals are precisely se which have been encountered and surmounted by successive ierations of mineralogists in the past. In the space at his comnd, the author can of course do little more than sketch in brief line the evolution of our knowledge concerning the crystallophic forms, the chemical composition and the physical properties minerals, but so admirably is this done that we cannot refrain m expressing a wish that the excellent method of the author uld be fully developed. A handbook of mineralogy, constructed the same lines, would be of immense service to the student, and uld go far towards redeeming mineralogy from the reproach it loubtedly suffers under at present, of being one of the dullest sciences.

Students have, however, abundant cause for gratitude to the eper of the Mineral Collections for what he has already done for m, by the selection from the rich stores of the Museum of admirable ies of specimens illustrating the chief characters of Minerals. e different systems of crystallization, the variations in the development of crystal faces, the formation of twins, and crystalline gregates, together with illustrations of dimorphism, trimorphism, morphism and pseudomorphism, are all exemplified in this way. milarly, the physical properties of minerals are illustrated by ries showing the scales of colour, lustre, and other optical characterics; of cleavage, fracture, structure, and of those other properties hich can only be determined by experiment. More advanced udents will find in the very large collection of wood models of ystals, of natural and artificial crystals, and of different varieties of eudomorphs, abundant materials demanding their attention.

The systematic collection remains in much the same condition as was at Bloomsbury, except in so far that the increased space has rmitted of diminished crowding of specimens, and of the introiction of fresh varieties. No classification of minerals is likely to mmand universal assent, and that employed at the Museum may irly claim to present as many advantages and as few disadvantages any of its rivals.

Persons in the constant habit of consulting the Collection will id that, by a very thoughtful arrangement, recent additions by irchase or donation are exhibited in a special case for a short time evious to their dispersion through the Collection.

We are glad to find from this guide that the Keeper of the ollection is alive to the fact that Mineralogy forms the Alphabet Petrography. Time has not yet permitted of the arrangement of e Rock-Collections of the Museum; and, until this is done, the lineral Gallery remains incomplete in one of its most important epartments. The general public, as well as students, will find uch of interest in the Pavilion, where, in addition to the meteorites, e gathered together many remarkably large examples of special iinerals and rocks, with illustrations of their economic value.

J. W. J.

III.—A Treatise on Ore Deposits. By John Arthur Phillips, F.R.S., V.P.G.S., F.C.S., etc. Royal 8vo. pp. 652, and xvi. with 95 Illustrations. (London: Macmillan & Co., 1884.)

MR. PHILLIPS is well known as a high authority on all matters relating to Mining and Metallurgy; his "Manual of Metallurgy," and his "Mining and Metallurgy of Gold and Silver," being standard books of reference.

In the present work the author has been assisted by Mr. B. H. Brough, A.R.S.M., and the illustrations are from the pencil of Mr. Frank Rutley. The subject is treated in the broadest and most cosmopolitan manner, every country in which mining operations are carried on being more or less fully noticed. Commencing with Ore-deposits in general, the author writes:—"Metals which occur in a state of approximate purity are said to be *native*, and when two or more such metals are found in combination, the mixture is called a *native alloy*. Usually the metals sought after by the miner are, however, not found in the native state, but are mineralized by uniting with various non-metallic bodies. In this way they combine with sulphur or chlorine, giving rise, respectively, to metallic sulphides or chlorides; with oxygen the metals form oxides, and with acids they yield salts, such as carbonates, sulphates, and phosphates.

"All natural combinations of a metal with such mineralizing substances are called *ores* when the proportion of metal which they contain, after suitable mechanical preparation, is sufficiently large to admit of their being advantageously treated by the metallurgist. Although perhaps not strictly correct, any material obtained by mining that contains a workable proportion of a metal is often called an ore, even if the whole of the metal be present in the native state.

Ores of the different metals are sometimes found in surface-deposits, disseminated through igneous and sedimentary rocks, in more or less regularly stratified or bedded formations, in detached masses, and, above all, in *veins* of various descriptions. The non-metalliferous minerals forming part of the latter are known as the *matrix*, *gangue*, or *veinstone*. Metalliferous minerals are found in rocks of every geological age; but they occur most frequently in mountainous districts, and in the older rocks, especially near junctions of igneous rocks with those of sedimentary origin. They are also frequently met with in strata which have either been penetrated by eruptive dykes, or have been subjected to extensive metamorphic alteration. The ores of each of the different metals are, however, often restricted within certain geological horizons, beyond which they seldom occur in remunerative quantities.

"Gold, platinum, and tin ore are found in alluvial detritus, in which they evidently were not formed by chemical action, but result from the disintegration of older deposits whose constituents have been removed and re-arranged by the mechanical agency of water.

"The fragments constituting the superficial deposits are usually much water-worn, and the associated metals or metalliferous particles are mainly concentrated in particular areas, over which water has flowed with great activity. Metalliferous deposits of this kind are usually of comparatively recent date, and are generally not older than the Tertiary period. Localities in which alluvial detritus is washed for gold are known as *placers*, but when tinstone is the ore sought after they are called *streamworks*.

"The ores of iron and manganese are almost the only metalliferous minerals usually occurring in stratified beds, those of nearly all the other metals being obtained from some other variety of mineral deposits.

"Although aluminium and magnesium are now regularly produced upon a small scale, they can scarcely be classed among metals derived from metalliferous ores in the sense in which that term is usually understood. The same may be said of sodium, which is chiefly employed in the preparation of the two above-mentioned metals.

"Metalliferous deposits are found in such varying forms, and under such differing circumstances, that it might at first appear difficult to classify them in accordance with their characteristic peculiarities and modes of occurrence. A careful study of their origin, structure, and composition appears, however, to justify their division into the following groups :—

- I. SUPERFICIAL.
  - *a.* Deposits formed by the mechanical action of water.
  - *b.* Deposits resulting from chemical action.
- II. STRATIFIED.
  - *a.* Deposits constituting the bulk of metalliferous beds formed by precipitation from aqueous solutions.
  - *b.* Bedso riginally deposited from solution, but subseqeuntly altered by metamorphism.
  - *c.* Ores disseminated through sedimentary beds, in which they have been chemically deposited.
- III. UNSTRATIFIED.
  - *a.* True veins.
  - *b.* *Segregated* veins.
  - *c.* Gash veins.
  - *d.* Impregnations.
  - *e.* Stockworks.
  - *f.* Fahlbands.
  - *g.* Contact deposits.
  - *h.* Chambers or pockets."

The author next proceeds to describe the nature of those ore-containing superficial deposits which have been formed by the mechanical action of water.

He gives a graphic description of the auriferous gravels of California and the method of obtaining the gold therefrom by hydraulic mining.

The gravels of Victoria, which are approximately of the same geological age as those of California, more frequently represent the beds of ancient rivers whose valleys have since been covered up by volcanic outflows. Here hydraulic mining cannot be successfully employed, and mining beneath the lava-capping has to be resorted to instead (p. 7).

The Tin Stream Works of Cornwall are well described, and present many features akin to those in which gold instead of tin forms the metal to be sought for.

We next pass on to stratified rocks containing ore-deposits, such as limonite, hæmatite, argillaceous ironstone and carbonate of iron, the various kinds of which, with their mode of occurrence, are noticed.

The copper-bearing shales of Mansfield, in Prussian Saxony, are described, as illustrating sedimentary beds in which ores have been chemically deposited.

We next pass to the ore-deposits met with in unstratified rocks which, with the exception of iron and manganese, yield by far the larger proportion of the metalliferous minerals.

The nature of true veins and all the varieties which they present, and their behaviour and distribution, occupies a very considerable space, and is well illustrated by numerous woodcuts.

This concludes Part I. and the first 108 pages of the book.

Part II., which occupies 516 pages, is devoted to a description of the Ore-deposits of the Principal Mining Regions, and so with Mr. Phillips for our guide we traverse England, France, Belgium, Germany, Italy, Greece, Spain, Portugal, Sweden, and Russia. Still, with untiring energy, we investigate the mineral resources of Asia, and then set sail with our guide for Oceania, visiting the Dutch East Indies, Japan, and the Australasian colonies; then turning to Africa, we find mining in a more backward state in the dark continent than elsewhere, although the prospects of the future for the Transvaal gold fields may perhaps be hopeful.

In Namaqualand, mining for copper ore seems to promise good returns.

The Two Americas naturally demand and receive a fair share of attention, having more than 100 pp. devoted to their ore-deposits.

The influence exercised of late years on our currency by the enormous output of silver in North America is evidenced by the table given at p. 557, where the weight and value of the precious metals produced in the United States alone, for the year ending 31 May, 1880, shows:—

Gold in ounces	1,614,741		
Silver „	31,797,474		
Having a total value of	£14,898,124	0*s*.	0*d*.
The former of which would represent about	£6,620,438	0*s*.	0*d*.
Whilst the latter would amount to about	£8,277,686	0*s*.	0*d*.

Space does not permit us to give a fuller notice of Mr. John Arthur Phillips' most useful volume, although its merits deserve it. The book is provided with an excellent index, and, he who *mines* may *read*, and we are sure he will find this volume a most valuable and instructive guide in whatever part of the globe his lot may be cast.

IV.—ON THE SILURIAN GASTEROPODA AND PTEROPODA OF GOTLAND. By G. LINDSTRÖM. With 21 Plates. Communicated to the Royal Swedish Academy of Sciences, June 8th, 1881, and April 9th, 1884. Kongl. Svenska Vetenskaps-Akademiens Handlingar, Bandet 19, No. 6. 4to. pp. 250. Price 16s. (Stockholm, 1884: P. A. Norstedt & Söner; London, Trübner & Co.)

PROFESSOR LINDSTRÖM, so favourably known as an authority on Silurian and Devonian Corals, has turned his attention to the fossil Mollusca of the Isle of Gotland, and this splendid monoraph contains the results of his researches on the Gasteropoda and teropoda from the Silurian strata of that locality, so famous for the umber and perfect condition of its fossils.

The author gives a preliminary sketch (accompanied by an outline ap) of the strata and the different localities in which the fossils ccur, and indicates the physical conditions which probably prevailed t the time the Mollusca flourished. It appears that the lowest beds Gotland are shales, occasionally replaced by sandstones, from 20 100 feet in thickness. The lowest zone of these shales contains *tricklandinia lirata*, *Euomphalus Gotlandicus*, *Pleurotomaria qualriata*, var., and a species of *Harpes*, and it corresponds with the pper Llandovery of this country; all the beds above this zone are Wenlock age, though they occasionally contain fossils which have en thought to characterize Upper Ludlow rocks. In the lowest vision, 65 species of Gasteropoda are present, 29 of which are mited to it, whilst 36 pass upwards to the beds above. These const of thin flaggy limestones, with seams of coarse marly shales, in l about 70 feet in thickness, which occur in Northern and Central otland; but in the South of the Island they are replaced by a arse pisolitic or oolitic rock, not more than 20 feet in thickness. rom this division 64 species are known, but only 12 are peculiar to . Succeeding this division are beds of so-called crinoidal limestone, least 150 feet in thickness, which cover a wide area in the Northern d Central portions of Gotland. In some places this limestone is most exclusively composed of crinoidal remains, whilst in others, ther Corals, Brachiopods, Lamellibranchs, Gasteropods, or Cephapods predominate to the exclusion of other forms. This upperost division of the strata of the island is by far the richest in asteropoda, having 124 species, of which 81 are peculiar to it.

The state of preservation of the shells is, of course, variable in the fferent strata, but it presents some peculiarities not readily acunted for. Thus in the shales of one locality only the casts or oulds of the shells are preserved, whilst in the same beds but a ort distance apart, the shells themselves are retained. Again, hilst some genera are only represented by casts, others interingled with them in the same beds and locality possess perfect ells, which probably indicates original differences in the chemical mineralogical constitution of the different genera.[1] The shells, when esent, are now mostly of a crystalline calcite, but in some the intiate structure can be recognized, and in certain examples even the ttern of the original colour-bands and traces of the nacreous lustre.

Out of a total fauna of 1007 species in the Silurian strata of otland, the Gasteropoda and Pteropoda number 174 species, belongg to 25 genera. But a very small proportion of these has been cognized beyond the limits of Gotland, and only the following 13 ecies are common with the Silurian strata of this country, viz. *latyceras cornutum*, His., *Platy. spiratum*, Sow., *Pleurotomaria limata* =*Euomphalus carinatus*, Sow.), *P. labrosa*, Hall, *P. alata*, His.,

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[1] See H. C. Sorby, F.R.S., "On Structure of Shells," Anniversary Address to ol. Soc. Lond. *1879, pp. 56-93, Quart. Journ.* Geol. Soc. vol. xxxv.

P. Lloydii, Sow., *P. bicincta*, Hall, *Bellerophon trilobatus*, Sow. *Loxonema sinuosum*, Sow., *Oriostoma discors*, Sow., *O. rugosum*, Sow *O. sculptum*, Sow., and *Cyclonema carinatum*, Sow. Four species als occur in the corresponding strata in North America, but none i Bohemia.

With the exception of the genus *Chelodes*, which belongs to th *Chitonidæ*, and the genera *Subulites*, *Euchrysalis*, and possibl *Onychochilus*, which, judging from their apertural characters, belon to the Siphonostomata, the Gotland Gasteropoda are included in th Holostomata. Twelve *recent* families are probably represented but there is some doubt whether the forms which have been referre to the Litorinidæ, Pyramidellidæ, and Turbinidæ rightly belong t these groups. Of the twenty-five genera, only two, *Pleurotomari* and *Trochus*, still remain in existence. Though *Pleurotomaria* ha not yet attained the maximum development which it reached i Jurassic times, yet even here, in conjunction with *Murchisonia*, forms about one-third of the species. Some degree of uncertaint inevitably attends the affinities of many of the Silurian Gasteropoda recent forms with which they have been associated, but there a some in which the resemblances are too striking for any doubt to b felt respecting their real relationships. Thus, for example, the muscul scars on the interior of *Tryblidium*, Linds., clearly prove its allian with the Patellidæ, and the Oriostomata show by the operculum ar the nacreous inner layer that they can be safely included in th Turbinidæ.

The author thinks that the worn and abraded condition of man of the shells and the presence of members of the Chitonidæ an Patellidæ indicate a littoral character for the fauna, and from th presence of *Pleurotomariæ*, *Trochi*, and the large Pteropods, that existed under tropical conditions.

The greatest number of species of Gasteropoda recorded fro Gotland by previous writers did not exceed 23. Murchison, in h paper,[1] "On the Silurian Rocks of Gotland," only enumerates species, whilst Dr. Bigsby in the "Thesaurus Siluricus" catalogu 30; but some of these are synonyms and others arose from th curious mistake of supposing that the word 'Steinkern,' whic appears in Helmersen's list after some of the genera, really mea the specific name.

The remarkable increase in the number of the species described this volume is owing to the abundant materials which, through car ful collecting for a long series of years, have been gradual accumulating in the Swedish State Museum of Natural History Stockholm, where the typical forms are now preserved.

We can only comment very briefly on the detailed descriptions the genera and species which have been thoroughly worked out b the author in such a careful manner, that whatever opinions may b held as to the names and systematic position of the various specie there can be no difficulty in their identification.

Commencing with the Pteropoda, five species of *Conularia* a described, four of which are new forms. The author discusses the question of the affinities of this genus to recent Pteropods, which have been disputed by Haeckel and Neumayr, and points out the significant fact that, with other resemblances, there are, in some fossil species, two peculiar longitudinal septa on the inner surface of the shell, similar to those present in several of the Cleodoræ and Styliolæ.

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[1] Quart. Journ. Geol. Soc. 1847, p. 29.

Some small detached shelly plates, with conical or cordate outlines, are regarded by the author as belonging to the Chitonidæ. They were named *Chelodes* by Davidson and King, who thought that they might have formed part of an operculated coral. Their affinities to *Chiton* are not altogether free from doubt, since the two apophyses on the anterior margins of the plates or valves of recent *Chitons*, are wanting in these fossil forms. They are, however, similar to the forms placed by Barrande under *Chiton*, and the author has discovered that their surface ornamentation entirely agrees with that of the Chitonidæ. Their symmetrical form indicates that they do not belong to the pedunculate cirripedes.

To the family of the Patellidæ belong two species of *Tryblidium*, Linds. In this genus the muscular scars occur as six disconnected pairs, arranged in a somewhat elliptical form, and the apex of the shell is anterior. It approaches very closely to *Metoptoma*, Phill., but this form has a truncated area below the apex, which is directed backwards, and the muscular impression is said by De Koninck to be continuous.

For the conical shells usually known in this country under the names of *Capulus* or *Acroculia*, Lindström adopts Conrad's name of *Platyceras*, and he includes also in this genus *Platystoma*, Conr., *Orthonychia*, *Igoceras* and *Strophostylus*, Hall, and *Naticopsis*, M'Coy. The examples of this genus exhibit great variations in form; to this may be owing the long list of synonyms of *P. cornutum*, the commonest of all the Gasteropoda of Gotland.

The family Bellerophontidæ, represented by the genera *Bellerophon*, Mont., *Cyrtolites*, Conr., and *Tremanotus*, Hall, is regarded as belonging to the Gasteropoda and nearly allied to *Haliotis*. As synonyms of the typical genus are included *Bucania*, *Carinaropsis*, and *Phragmostoma*, Hall, and also *Waagenia* and *Waagenella*, de Koninck. No fewer than 13 species of *Bellerophon* are recorded from Gotland, all of which are new, with the exception of the widely-distributed *B. trilobatus*, Sow. There are also seven new species of *Cyrtolites* and two of *Tremanotus*. One of these latter, *T. longitudinalis*, is, however, identical with *Bellerophon dilatatus*, Sow.; as the type specimen of this form shows distinct traces of the characteristic apertures on the dorsal keel, though they are not mentioned either by Sowerby or by M'Coy, who more fully described the species.

The family Pleurotomaridæ, including *Pleurotomaria* and *Murchisonia*, is represented in Gotland by 39 species of the former and 15 of the latter genus, the large majority of which are new forms.

The following genera are included by the author in Pleurotomaria; *Inachus*, His., *Scalites*, Conr., *Raphistoma*, Hall, *Helicotoma*, Salt., *Euomphalopterus*, F. Roemer, and *Gosseletia*, *Agnesia*, *Luciella* and *Mourlonia*, De Koninck. Remarking on the absence of any satisfactory distinction between *Murchisonia* and *Pleurotomaria*, Lindström proposes that the forms with elongated slender spires of more than six bead-like whorls, should be retained under the former genus. The numerous species of *Pleurotomaria* are ranged in eight subdivisions, mainly based on the characters of the slit-band. Some of the Gotland shells yet retain their inner nacreous layer and the minutest details of their surface-ornamentation.

It appears that the well-known Silurian species *Euomphalus carinatus*, Sow., possesses a distinct slit band and therefore must be removed to *Pleurotomaria*, and as its specific name is already preoccupied, the author proposes to give it the name *P. limata*. For a similar reason *Euomphalus alatus*, Wahl., is also placed in *Pleurotomaria*.

In the family of the Euomphalidæ are included *Euomphalus* and *Loxonema*, and five species of each of these genera are described. The author restricts *Euomphalus*, Sow., to the forms, such as *E. pentangulatus*, which were first placed in it by Sowerby.

With some diffidence the author places in the old-established genus *Trochus* 16 species, which all occur in the limestone strata, none having yet been met with in the underlying shales. This genus has hitherto been regarded as commencing in the Devonian, but the author believes that the close resemblance in outer form of these Silurian species justifies their inclusion in this genus, although neither the opercula, nor traces of the nacreous layer, have as yet been discovered, and the microscopic structure of the shell is not preserved.

A new genus, *Pycnomphalus*, is formed for trochiform or globose shells with a thick callosity on the inner lip surrounding the umbilicus. The genus is allied to *Umbonium* (=*Rotella*, Lam.).

In the family of the Turbinidæ are ranged the genera *Oriostoma*, Mun. Chal.; *Cyclonema*, Hall; *Trochonema* and *Eunema*, Salt.; and *Craspedostoma*, n.g. Many of the forms of this group yet retain the nacreous lustre of the inner shell-layer, and they possess a solid shelly operculum, not infrequently found in situ. Under *Oriostoma*, Mun. Chal., are included the familiar forms hitherto known as *Euomphalus discors*, *E. rugosus*, and *E. sculptus*, Sow.

A new genus, *Autodetus*, is created for the peculiar minute attached shells placed by Schrenk under *Capulus*.

Holopea, Hall, with five species, is placed in the Litorinidæ, and *Callonema*, Hall, with *Holopella*, M'Coy, in the Scalaridæ. *Macrochilina*, Bayle, with three species, is included in the Pyramidellidæ.

The genus *Subulites*, Conrad, gives its name to a family, which, with *Euchrysalis*, Laube, and the provisional genus *Onychochilus*, Linds., includes the earliest known representatives of the Holostomata.

Before concluding our notice, we must express our admiration at the beautiful manner in which the plates are executed. The minutest details of the surface-markings of the shells are shown with marvellous clearness and precision, and the shells themselves are, for the most part, in such perfect preservation that, in looking over the plates, we can scarcely realize that the figures represent fossil forms of Silurian age. Prof. Lindström has in this monograph extensively increased our knowledge of the Silurian Gasteropoda, and all students of Palæozoic fossils are indebted to him for this fresh contribution to palæontology. The working palæontologists of this country and America are under special obligations to him for bringing out this work in the English language, and thus affording, to not a few, readier access to its contents. It is a bold undertaking for an author to write an important monograph like this in a foreign language, especially when that language is English, and we congratulate Prof. Lindström on the success attending his effort. Nor ought we to forget the munificence of the Royal Swedish Academy of Sciences in finding the funds for publishing this work.

When we consider the numerous admirable scientific memoirs which this Royal Academy has lately published, notably amongst others the magnificent memoir on *Pourtalesia*, by Prof. Loven, the colleague of Prof. Lindström in the Royal Museum at Stockholm, we feel that the contrast between the scientific activity in Sweden and the support it receives, and the condition of things in this country, is not altogether flattering to ourselves. G. J. H.

V.—ANNUAL REPORT OF THE GOVERNMENT GEOLOGIST FOR SOUTH AUSTRALIA (HENRY Y. LYELL BROWN, F.G.S.), December 1st, 1882, to December 31st, 1883. Fol. pp. 20; with nine page-sections and plans, and one large folding chromolithographic map of South Australia, exclusive of the Northern Territories. (Adelaide: September, 1884.)

THE first Annual Report of the Geological Survey of South Australia was noticed by us in this MAGAZINE (Decade III. Vol. I. January, 1884, pp. 29–32), and it is highly gratifying to find that Mr. H. Lyell Brown has been able to compress so large an amount of work into the thirteen months which are embraced in the present publication.

It is difficult for any one here in England to realize either the vast extent of the territory of South Australia (ten times that of Great Britain) or the almost entire absence of easy and rapid means of intercommunication between its widely-spread and thinly-scattered population. No wave of gold-field-fever has as yet disturbed the agricultural calm of this large and well-to-do Colony; but there has arisen a very natural desire, on the part of its Government and people, to know what are the Mineral resources of the Colony. Mr. Lyell Brown has set to work with a will to furnish this information to the Government, and has sacrificed all considerations of personal ease and comfort to travel over many thousand miles of country in order to produce the admirable sketch-map of the Geology of South Australia which accompanies the present report.

The project for a trans-continental railway from Adelaide in the South to Port Darwin in the North, upwards of 1400 miles, has only as yet resulted in a line from Adelaide to Hergott Springs, a length of about 350 miles. The success which has attended the deep Artesian well-boring at Hergott Springs (carried down to a depth of about 1200 feet, and which yields about 3000 gallons of water per diem, rising with an elevatory force of some 60 feet above the surface), renders it probable that other wells sunk along the same synclinal trough will yield an equally abundant supply of this indispensable necessary for railway locomotion through an otherwise almost waterless region. Another proposed railway is being surveyed, which will connect Adelaide with Melbourne.

From the Map it will be seen that between 135° and 141° East long. and from South lat. 26° to 32°, the entire area is occupied by Cretaceous and Oolitic rocks (with or without overlying Tertiary beds); save one great mass of Palæozoic rocks, which stretches from Encounter Bay and Kangaroo Island in the South to Mount Distance and Mount Nor-West in the North, occupying the region between Lake Torrens on the West and Lake Frome on the East. The Nullarbor Plain, at the head of the Great Australian Bight, and the district of the Murray River, between Adelaide and Victoria, is coloured Lower Tertiary. Granite, Syenite, Porphyry, etc., is largely developed along the 26th parallel of latitude from 129° to 133° of East Longitude, and sporadically in all the metamorphic areas, near Fowler's Bay, at the head of the Bight; on the Murray River near Murray Bridge, and in the highly metamorphic area running parallel to the Palæozoic series from Encounter Bay to Thackaringa (lat. 32° S.).

In the Report will be found a careful account of the Woodside Gold-mines, accompanied by a geologically coloured plan, giving the position of the principal reefs of the District.

Next follow Reports of favourable places for well-sinking, and Examinations of well-borings in numerous parts of the Colony, with the probable prospects of water-supply, as at Wilmington, Wallaroo, Dublin, Percyton, Waukaringa, Gawler, between Wellington, and across the Ninety-Mile Desert, etc.

In most of these places the formation of the country and the lie of the rocks is favourable to water-supply by means of Artesian-borings, and, after covering the first expense, it is probable that water for the Colony will in the future be secure, even in the 'so-called' *Desert* regions.

In the Palæozoic and Metamorphic region, stretching from Thackaringa to Beltana, there is a prospect of workable gold-washings in the alluvium and also of quartz-crushing at a paying rate, if only the difficulty of water can be overcome.

A considerable portion of this country is underlain by a limestone formation which is always found to be favourable to the natural storage of water underground. Seventeen wells are enumerated on one route from a few feet to one of 377 feet (a tubed bore) at Curnamoona Station.

The following is a list of the rocks referred to in this Report in descending order, with their ages provisionally given:—

1. TERTIARY.—Sand, clay, gravel and conglomerate; gypsum and rock-salt.
2. CRETACEOUS.—Table land formation, sandstone, Kaolin, grit, and conglomerate; clay and sandy beds with gypsum, ironstones, sandstones, limestones, and calcareous clays in horizontal beds.
3. DEVONIAN (?)—Claystones and conglomerates, skirting the Flinders range and elsewhere.
4. SILURIAN (?)—Limestones, clayslates and shales, quartzites, calcareous slates, sandstones, siliceous and conglomeratic limestones.
5. METAMORPHIC.—Clay slates, mica slates, and schists, with granite dykes.
6. GRANITE and GREENSTONE.

Gold is obtained at Echunga in drifts and alluvial gullies. At Woodside, auriferous quartz-reefs are worked. Eleven other localities are recorded where alluvial gold-mining and quartz-crushing has been carried on. "The great drawbacks are however the scarcity of water for washing purposes, the inaccessibility of the land to prospectors, through its having been alienated from the Crown, and the remoteness of some of the localities from civilized life and the consequent difficulty of obtaining supplies."

Copper-mining appears to form an important item in the mineral-resources of this Colony. Thirty-two mines are enumerated, five of which are being worked at the present time. In 1882 the export of copper was 3,647 tons, valued at £249,884; copper ore, 1,294 tons, value £195,686.

Lead ore, Galena, Cerusite, Bismuth, Antimony and Nickel, Cobalt, Rutile, Manganese, Tin and Graphite are among the minerals found more or less abundantly, but in the absence of any returns they cannot yet be treated as of commercial importance. A list of Minerals by Mr. G. Goyder, jun., completes this excellent report.

In his summary addressed to the Commissioner of Crown Lands, Mr. Henry Y. Lyell Brown mentions the appointment, as Assistant Geologist, of Mr. Harry P. Woodward, F.G.S., who arrived out in the Colony in July, 1883. After mapping part of the Mt. Lofty range, and the gold-field reserves of Kutipo and Noarlunga, he was sent in December, 1883, as Naturalist, with Mr. Poeppel's expedition to Survey the Boundary-line between Queensland and South Australia, on which service he was engaged until September, 1884, when, owing to the want of transport in this barren Sand-hill District, he returned to Adelaide to resume his regular Geological Survey work under Mr. H. Y. L. Brown.

REPORTS AND PROCEEDINGS.

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GEOLOGICAL SOCIETY OF LONDON.

I.—November 19, 1884.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the chair. The following communications were read:

1. "Note on the Resemblance of the Upper Molar Teeth of an Eocene Mammal (*Neoplagiaulax*, Lemoine) to those of *Tritylodon*." By Sir Richard Owen, K.C.B., F.R.S., F.G.S.

In this paper the author referred to the genus *Neoplagiaulax*, described by M. Lemoine from the Eocene of Rheims, as presenting premolars so like those of the Mesozoic genus *Plagiaulax* as to have suggested the above name, while the true molars in the upper jaw resembled those of his South-African genus *Tritylodon* even more nearly than those of *Microlestes* and *Stereognathus*, with which the latter were compared. The lower molars of *Neoplagiaulax* have two instead of three longitudinal series of tubercles; and the author suggested that this may have been the case also in *Tritylodon*; and that the detached molars, on which the genus *Microlestes* is founded, may also belong to the lower jaw.

2. "On the Discovery in one of the Bone-caves of Creswell Crags of a portion of the Upper Jaw of *Elephas primigenius*, containing, *in situ*, the first and second Milk-molars (right side)." By A. T. Metcalfe, Esq., F.G.S.

The specimen exhibited to the Society and now described was obtained from one of the Creswell bone-caves, before the commencement of their systematic exploration by a Committee of the British Association. The bone-caves are in the Lower Magnesian Limestone of the Permian, not far from the southern limit of that deposit near Nottingham. The locality was described, and it was shown that the ravine in which the caves occur has been cut in the limestone by the little river Wollen, which probably began by excavating a cavern the whole length of the ravine. The roof of this cavern must have fallen in, and the minor lateral caverns, in which bone-deposits are found, are now similarly being converted into side ravines.

The fossil was found in "Pin-Hole Cave," the most westerly on the north or Derbyshire side of the ravine, about six inches below the base of the surface-soil, here four inches deep. The cave has been described in the Society's Journal, vol. xxxi. p. 679, by the Rev. J. M. Mello, who in 1875 obtained from this spot bones of the Arctic fox (*Canis lagopus*). As the mammoth teeth (first and second milk-molars of the upper jaw) occurring in the fossil were wanting in the National Collection, the author has undertaken to present the specimen to the British (Natural History) Museum.

3. "Notes on the Remains of *Elephas primigenius* from the Creswell Bone-cave." By Sir R. Owen, K.C.B., F.R.S.. F.G.S., &c.

The author noticed the various descriptions by Cuvier and himself of milk-molars of *Elephas primigenius*, and pointed out that all hitherto known were found detached. The present is the first known occurrence of the two earliest milk-molars *in situ*. The specimen discovered by Mr. Metcalfe is a portion of the fore part of the maxilla of a very young Elephant with the teeth of the right side preserved, the corresponding teeth of the left side and their sockets having been broken away. Of the two teeth thus obtained descriptions and measurements were given. The first tooth is much worn, but only the anterior portion of the second has undergone wear, the two hindmost divisions of this tooth not having risen into use.

It shows that these first teeth of *E. primigenius* differ much less from the corresponding milk-molars of the Indian Elephant than the later teeth do, the thickness of the constituent enamel-plates being but little less in proportion, and the principal distinction being the greater relative breadth of the second molar, especially towards the base of the crown.

4. "On the Stratigraphical Position of the Lower and Middle Jurassic *Trigoniæ* of North Oxfordshire and adjacent districts." By Edwin A. Walford, Esq., F.G.S.

The author spoke of the value of the *Trigoniæ* as stratigraphical guides and of the wealth of the Oolitic deposits of North Oxfordshire in number of species as well as of individual forms. He alluded to the recent discovery by Northampton geologists of *Trigonia literata* and *T. pulchella* in the centre of their county. By the presence of certain *Trigoniæ* as well as of corals and bored stones he endeavoured to prove the extension of a stratum at the base of the *Clypeus*-grit at Fawler, as far as Hook Norton, also in North Oxfordshire, where the bulk of the Inferior Oolite was of an altogether different type. In Mr. Walford's list were nearly thirty species and varieties from the Bajocian beds. To the lower horizons there belonged but one local form and no species of special stratigraphical value. The presence of a few other fossils supposed to be characteristic was the only evidence of beds below the zone of *Ammonites Murchisoniæ*. Series C, which appeared to be of the age of the lower *Trigonia*-grit, had yielded the greater part of the *Trigoniæ* mentioned, several of them being peculiar to the horizon, whilst others were local species. The higher beds had yielded some apparently undescribed forms, whilst hitherto unrecorded species were quoted from the Great Oolite and Forest Marble. One species (*T. Lycettii*) was described as new.

II.—December 3, 1884.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair. The following communications were read:

1. "Note on a Section near Llanberis." By Prof. A. H. Green.

In this paper the author described a section showing actual unconformity at the base of the Cambrian. In one of the cuttings on the railway that runs from the Dinorwig quarries along the north-western shore of Llyn Padarn, the basement conglomerate of the Harlech and Llanberis group, dipping N.W. at a moderate angle, rests upon vertical slaty beds, one of which is a breccia. The author believes that the section described is one of which a different reading was given by Sir A. Ramsay in the Geological Survey Memoir on North Wales. In that work the conglomerate was regarded as a continuation of the breccia of the underlying beds sharply turned over.

The microscopic characters of the lower series show that these beds are probably coarse volcanic tuffs, and that they resemble the rocks at St. David's, called Pebidian by Dr. Hicks. The unconformity observed does not necessarily indicate great difference of age between the conglomerate and the underlying beds. In volcanic rocks such breaks may be merely local.

Further north-west, in the same railway section, a junction is seen between the Cambrian conglomerate and quartz-felsite. It is uncertain whether the junction is a fault or not. The matrix of the conglomerate is chiefly composed of felsite fragments so perfectly cemented together as to bear a close superficial resemblance to the original rock even under the microscope, unless a high power be used.

2. "The Tertiary Basaltic Formation in Iceland." By J. Starkie Gardner, Esq., F.L.S., F.G.S.

The country explored stretches from the N.E. corner to the S.W. Every locality in which lignite had been met with was visited. The most northerly of these, at Húsavik, presents a coast-section showing 200 feet of tuffs with bands of lignite, 200 feet of the same with marine shells, and an immense series of overlying tuffs, which are unfossiliferous, and were followed, ten miles further north, to Tjórnes, almost within the Arctic Circle. The shells, a series of which were exhibited, indicate a warmer sea, and, in the author's opinion, are of an age a little anterior to the Crag. It is hoped that Dr. Gwyn Jeffreys, who has several times examined them, may pronounce a definite opinion in regard to this. A number of sections towards the interior were visited, one of the finest being in a cañon near Hof, where the sides are upwards of 1000 feet high, and nearly vertical, exhibiting an alternation of semicolumnar basalts, ash-beds, and laterites, capped by rhyolites. These rhyolites are very beautiful, and cap the basalts over a wide area, being themselves overlain by other and more irregular streams of basalt and tuffs. The country has been subjected to immense denudation, and is cut up into rolling flat-topped hills such as characterize basaltic regions elsewhere. The horizon from which most, if not all, the fossil plants from Iceland have been obtained, is that of the rhyolites—a more recent series than any represented in the British Isles or even in the Faroes. Their age may have been correctly assigned to the Miocene.

CORRESPONDENCE.

RELATIVE AGES OF AMERICAN AND ENGLISH NEOZOIC SERIES.

SIR,—Mr. J. Starkie Gardner, in his memoir "On the Relative Ages of the American and the English Cretaceous and Eocene Series" (GEOLOGICAL MAGAZINE, November, 1884, p. 504), says, "Professor Marcou wrote that he considered all the supposed Cretaceous rocks of California to be Tertiary, but without going so far as that, there can be no question about the Tejon Group, at least, being of that age." This statement is erroneous.

In my "Note sur la Géologie de la Californie" (Bulletin Soc. géol. France, tome xi. p. 407, 1883), which I suppose is the paper referred to, I have described the Cretaceous rocks of the vicinity of Shasta-city as being the only region of California, so far as explorations have yet been made, where the Cretaceous rocks truly exist. It is what Mr. Starkie Gardner calls "the Shasta group," "held to be of the antiquity of the Gault." On that age nothing yet definite can be said; and I believe it is prudent to reserve expressing a decided opinion until more material has been collected and described.

As to the "Chico group" quoted as the "supposed equivalent to the Chalk formation of Europe," I have shown the palæontogical reasons why it should be considered as representing the lower part of the Eocene. At Chico creek, where it was first discovered, only two or three degenerate Cephalopoda have been found, amid a magnificent and very numerous fauna of Gasteropoda and Acephala, characteristic of true Lower Tertiary in America as well as in Europe.

The "Martinez group," also quoted as Cretaceous, is only a subdivision, composed of a few passage-beds without real value, and ought to be dropped.

Then comes the "Tejon Group," which Mr. Starkie Gardner admits as being Tertiary without question.

The Cretaceous series of North America are far more complete than represented in Mr. Gardner's paper; for he has overlooked entirely the Cretaceous rocks of Texas and the Lower Mississippi basin. The expression of "Lower Cretaceous" of America, as used by him, is misleading, for it means only the lower parts of the Cretaceous rocks of the basin of the Upper Missouri, where neither the Lower Cretaceous or even the Middle Cretaceous of Europe are found. It is even very doubtful if there is a representative of the Marly Chalk (*craie tuffeau de Touraine*) or "Turonian."

The "Dakota and Fort Benton groups" represent with their fossils, such as *Ptychodus* and other fishes, *Inoceramus*, etc., the White Chalk of Sens or "Senonian"; and certainly are not older than the lower part of the Upper Cretaceous rocks of England and France. All the upper divisions, called "Fort Pierre and Fox hills groups," are the representatives of the most upper part of the European Cretaceous rocks called "Danian," and which exist at Mäestricht, Aix-la-Chapelle, Ciply near Mons, Faxoë in Denmark, in Provence, and the Pyrenees.

The "Laramie group" represents the lower part of the European Eocene from the Pisolitic limestone of Paris, the Meudon clay, the Rilly limestone, the Paris Plastic clay, the Puddingstone of Nemours, the Soissonnais sands, the beds of the Isle of Thanet, as far up as the Middle Eocene of Sir Charles Lyell. It represents and corresponds to the "Chico group" of California.

And because *Mosasaurus* exists in the Laramie, that does not make it Cretaceous, any more than the existence of the degenerated *Ammonites* and *Baculites Chicoensis* at Chico Creek makes the "Chico group" Cretaceous. But it only shows that *Mosasaurus*, *Ammonites*, and *Baculites* existed in America at the beginning of the Tertiary period, when they had already finished their existence in Europe.

Cambridge, Massachusetts, United States, Jules Marcou.
November 12*th*, 1884.

THE CLASSIFICATION OF THE JURASSIC SYSTEM.

Sir,—I am indebted to Mr. A. J. Jukes-Browne's letter in the Geological Magazine for last November, for an opportunity of explaining my reason for proposing, in my note on the Classification of Sedimentary Strata, to draw the line of division between Upper and Middle Jurassic above the Oxford Clay.

I mentioned in my note that this was a doubtful question, and the weight of authority is in favour of Mr. Jukes-Browne's view, that is, of classing the Oxford Clay as Upper Jurassic, though many continental geologists consider the Kelloway Rock (Callovian) as pertaining to the Middle series, owing to the German equivalent belonging to the Dogger or Brown Jura. At the Zurich meeting of the

International Committee of Geological Nomenclature, in 1883, a majority voted in favour of the limit between the two divisions being drawn below the Callovian.

The lines of division to which geologists generally attach importance are breaks in the sequence, shown by unconformity or by changes in the sedimentation. Mr. Jukes-Browne very naturally wishes, as most other English geologists have done, to draw a limit where the calcareous deposits of the Middle Jurassics cease in England, and the argillaceous beds of the Upper Jurassics come in. Such a division, however well marked locally, has no general value, the change being confined to but a small portion of the earth's surface.

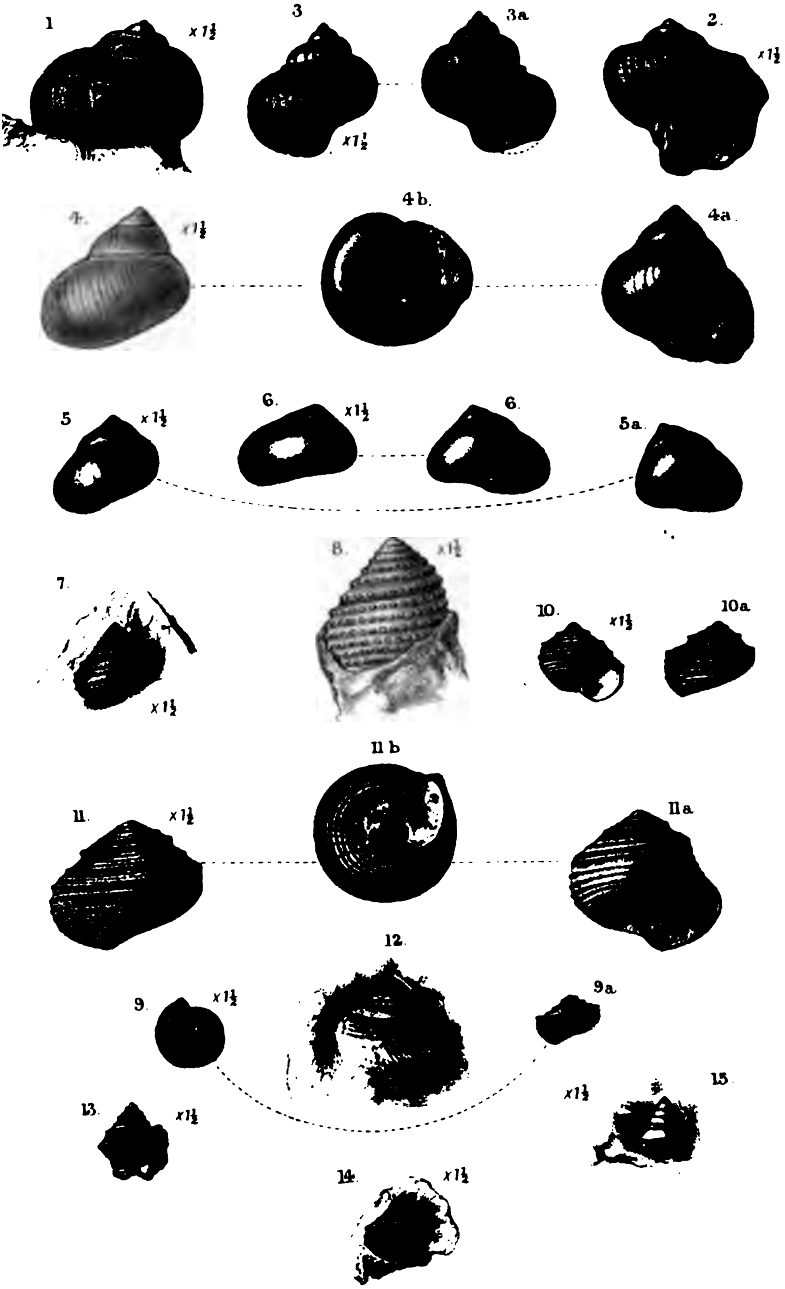
My reason for classing the Oxford Clay as Middle Jurassic is that, by so doing, the series or primary subdivisions of the system are more nearly equal in value. I take four fairly representative modern classifications, those of Renevier (1873–74), Meyer-Eymar (1881), Geikie (1882), and De Lapparent (1883). Under Renevier's arrangement, if the Oxford Clay (and Callovian) be classed in the higher series, the upper subdivision would contain 3 "*systèmes*" comprising 9 "*étages,*" the middle 1 "*système,*" and 4 "*étages.* By Meyer-Eymar's arrangement, the upper would contain 4 *étages* consisting of 12 *sous-étages*, (or if the Purbeck, classed by Meyer-Eymar in the Lower Cretaceous series, be added, as it would by most geologists, 5 and 14), the middle 3 *étages*, consisting of 8 *sous-étages.* In Mr. Geikie's classification two divisions would be assigned to the Upper Jurassic, one only to the Middle, whilst in De Lapparent's 4 *étages* with 11 *sous-étages* would belong to the former, and only 2 *étages* with 4 *sous-étages* to the latter. If on the other hand the Oxfordian and Callovian are classed with the Middle Jurassic, the difference in palæontological importance between that and the upper subdivision, under any of the systems of classification quoted, would be small.

I carefully abstained from proposing new names, as so many have already been given to various Jurassic subdivisions. Those proposed by Mr. Jukes-Browne have certainly an advantage, on the score of euphony, over the terms Malm and Dogger, but the latter are widely known.

I must deprecate the use of the term "stage," in the sense in which it is employed by Mr. Jukes-Browne. An English term is urgently required as the equivalent of the French *étage.* This is never used for divisions of the rank of upper, middle or lower Jurassic, but always for smaller terms such as Purbeck, Portland, Kimmeridge, etc. If "stage" is restricted to the same meaning, the term will be far more useful than if employed as loosely as, for instance, "group" and "series" have been.

November 19*th*, 1884. W. T. Blanford.

We regret to announce the death of Mr. Searles V. Wood, F.G.S., Treasurer of the Palæontographical Society, on Sunday the 14th December, 1884, at his residence, Beacon Hill House, Martlesham, Woodbridge, after an illness of nine years duration.



Mintern Bros. imp.

and Lower Oolite Gasteropoda:
Yorkshire.

THE

GEOLOGICAL MAGAZINE.

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No. II.—FEBRUARY, 1885.

ORIGINAL ARTICLES.

◆

I.—CONTRIBUTIONS TO THE PALÆONTOLOGY OF THE YORKSHIRE OOLITES.

By WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S.

(Continued from Decade III. Vol. I. p. 303.)

(PLATE II.)

67.—**NERITOPSIS (? TURBO) LÆVIGATA**, Phillips, 1829. Plate II. Figs. 1, 2, 3, 3*a*.

1829 and 1835. *Turbo lævigatus* (*Nerita lævigata*, Min. Conch.). Phillips, G.Y. p. 129, pl. xi. fig. 31.
1852 ? *Turbo gibbosus*, D'Orbigny. Terr. Jurass. ii. p. 342, pl. 330, fig. 1–3.
1854 ? *Monodonta gibbosa*, Thorent. Morr. Cat. p. 258.
1875. *Turbo lævigatus*, Phillips, G.Y. 3rd ed. p. 330, pl. xi. fig. 31.

Bibliography, etc.—The type specimen of *Turbo lævigatus*, Phil., has not been seen by me; but since there are some grounds for regarding the fossil, usually so described, as a *Neritopsis*, the identification becomes important. We must therefore fall back upon Phillips's figure, and upon such collateral evidence as, in the absence of description, may be available. Phillips in the early editions of the G.Y. considered Bean's specimen from the Dogger as identical with *Nerita lævigata*, Sow. (M. C. t. 217, fig. 1), which he regarded as a *Turbo* rather than a *Nerita*. This identification of Phillips has not been endorsed by subsequent writers. D'Orbigny believed that he recognized in *Turbo lævigatus*, Phil., *Delphinula gibbosa*, Thorent (Mém. S. G. Fr. 3, p. 260, pl. 22, fig. 10). D'Orbigny's figure, making due allowance for enlargement, is very similar to the one by Phillips.

There are two points in which D'Orbigny's description of *Turbo gibbosus* does not correspond with the Dogger fossils identified by me with *Turbo lævigatus*, Phil. (1.) *T. gibbosus* is described by D'Orbigny as having a smooth whorl. (2.) That author finds traces of a tooth on the columella. Neither of these peculiarities can be predicated of the Dogger fossils now under consideration. Therefore, without actually seeing Thorent's type, its identification with the shells I call *Neritopsis lævigata*, Phil., is not absolutely certain. At the same time, there are specimens from the Dogger, such as Fig. 3 of our Plate, where the fine spiral ornamentation is so obscure that, in another matrix, it might altogether escape observation.

As regards the traces of a tooth said to exist in Thorent's species, D'Orbigny's plate shows a strong callosity on part of the columella, but no actual tooth.

In Mr. Leckenby's collection these fossils are labelled *Nerita lævigata*, Phil. non Sow.: in the Scarborough Museum there is a large specimen labelled *Monodonta lævigata*, Phil. non Sow. This is at least collateral evidence that Phillips's figure (xi. 31) refers to the fossils now under consideration. Moreover, there are no other fossils forthcoming which answer to the Phillipsian species. Whether more than one species can be made out of the available specimens is a point which cannot be absolutely decided, though I have preferred to treat them as varieties.

Descriptions.—Variety A.—Specimen from the Dogger (zone 1), Peak (Blue Wyke). Leckenby Collection. Fig. 1.

Width	15 millimètres.
Spiral angle	110°.

Shell turbinate, transversely ovate; body-whorl large in proportion to the spire. Whorls about four, depressed, somewhat flattened at top, and separated by a wide and slightly channelled suture. Although apparently smooth, the shell, on closer inspection, is seen to possess a very fine and regularly undulating spiral ornamentation, decussated by broad lines of growth, especially visible on the flanks of the body-whorl. Aperture large and circular, but the anterior portion concealed in the matrix.

Another specimen.—Same horizon and locality. Jermyn Street Museum. Fig. 2.

Height	13 millimètres.
Width	14 ,,
Spiral angle	?
Ratio of body-whorl to entire shell about	80 : 100.

The spire of this specimen is in worse condition than the one previously described (Fig. 1); but the body-whorl is similar in shape and ornamentation, and probably also in relative size. Being free from matrix, the aperture is clear, though a portion of the outer lip and anterior extremity is deficient. Enough remains to show that the aperture was very wide and produced; with a long columella very slightly curved and much thickened by callus. No umbilicus.

Variety B.—Specimen from the same horizon and locality. York Museum. Figs. 3 and 3*a*.

Height	12 millimètres.
Width	12 ,,
Spiral angle	95°.
Ratio of body-whorl to entire shell	70 : 100.

Shell turbinate, subovate, imperforate; body-whorl large in comparison with the spire, but less so than in variety A. The entire shell consists of about five whorls, which are tumid, scarcely flattened atop, and separated by a suture of moderate depth. (N.B.—The appearance of a sort of belt over the suture, between the penult and body-whorl, correctly represented in Fig. 3, has no structural significance, but seems to be the result of one of those curious tricks which mineralization sometimes plays with the fossils of the Dogger.) The whorls are smooth—almost polished in the specimen—but a fine system of undulating spirals may be seen on close inspection, and these are decussated by broad flat lines of growth.

The aperture is wide, and subcircular, the outer lip being produced and slightly pouting; columella nearly straight and considerably thickened.

Relations and Distribution.—The above forms are by no means easy to allocate generically, and it is quite open to question whether the varieties A. and B. should not be more widely separated. Variety A., which is the least rare of the two, has the shell extremely depressed and neritoid, and the ornamentation so characteristic of the more delicately sculptured amongst the Jurassic Neritopsids is conspicuous in a good light without the aid of a lens. In this respect variety A. approaches *Neritopsis* (*Turbo*) *canaliculatus*, D'Arch., from the Cornbrash of Yorkshire, described in the last number of this Memoir.[3] There are a fair number of specimens in the best collections, but hardly any afford opportunities for a study of the aperture. The Jermyn-Street specimen (Fig. 2) is almost alone in this respect, and even in this one the conditions are not altogether favourable for a very accurate diagnosis. The late Dr. Lycett appears to have regarded this specimen as a *Neritopsis*.

Variety B. is very like Phillips's figure, and also like D'Orbigny's. Although it has many points of resemblance with A., yet there are important differences. The spiral angle is 15° less and the ratio of the body-whorl 10 per cent. less, and the aperture is relatively smaller, and more circular. Indeed the whole aspect of the shell is less like a *Neritopsis*. This variety must be regarded as the representative of Phillips's type. It is, however, very rare.

Both varieties occur sparingly in the Dogger, but as yet I have not identified them from the Inferior Oolite of the West of England. Supposing that variety B. is really represented by *Delphinula gibbosa*, Thorent, it occurs in the Inferior Oolite of St. Michel (Aisne), France.

Genus TURBO, Linnæus, 1758.

As previously intimated in the "Corallian Gasteropoda" (GEOL. MAG. 1881, p. 52), and also in a former part of the present Memoir, owing to the withdrawal of *Amberleya*, and the so-called *Littorinæ*, the number of species left to be classed under *Turbo* is limited. If we were further to withdraw the forms usually referred to *Monodonta* and *Delphinula*, there would be no representative of *Turbo* at all in the series of beds now under consideration. It must be admitted that, in the absence of certain characters easily recognized in existing species, it is extremely difficult to know how to treat the quondam *Turbos* of our lists: nay more, it is not always easy to say (when the aperture is concealed or imperfect) whether a species should be classed under *Turbo* or *Trochus*. Hence I am free to admit that the arrangements at present adopted are somewhat empirical, and thus the list of

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GEOL. MAG. Dec. III. Vol. I. p. 301.

Jurassic *Turbos* becomes large or small according to the views of particular authors.

That *Amberleya* and the so-called *Littorinæ* should be classed under the *Turbinidæ* rather than under the *Littorinidæ* is extremely probable. The title of the smooth forms of *Monodonta* to be separated from *Turbo*, because of the columellar tooth, which is very irregularly developed, is also doubtful, since there seems to be a singular connection between the small smooth *Turbos* of the Lias and the "Monodontas" of the Oolite. It is best to regard *Monodonta*, *Crossostoma*, etc., as merely of subgeneric value.

68.—TURBO (MONODONTA) LÆVIGATUS, Sowerby, 1821. Plate II. Figs. 4, 4*a*, 4*b*; 5, 5*a*; 6, 6*a*.

N.B.—In a general sense this should be viewed as a group rather than as one species. The references below must not in every case be regarded in the light of actual synonyms, but rather as representing sections of the group. Hence no chronological arrangement.

1821. *Nerita lævigata*, Sowerby. Min. Conch. pl. 217, fig. 1.
1854. *Monodonta lævigata*, Sowerby. Morr. Cat. p. 258.
N.D. *Nerita bellulata*, Bean MS.
1843. *Trochus Labadyei*, D'Archiac. Mém. Soc. Geol. Fr. vol. v. pt. 2, p. 379, pl. 29, fig. 2, 2*a*.
1852. *Trochus acmon*, D'Orbigny. Terr. Jurass. p. 278, pl. 314, figs. 1—4.
1860. *Monodonta papilla*, Héb. et Desl. Bull. Soc. Linn. Norm. p. 59 of sep. copy, pl. 3, fig. 1.
1867. *Chrysostoma ovulata*, Héb. et Desl. Laube, Gaster. von Balin, p. 13, pl. 3, fig. 3.

Compare also—

1850. *Crossostoma discoideum*, Morris and Lycett. Gt. Ool. Moll. p. 73, pl. xi. fig. 7.

Bibliography, etc.—Although specimens of this plentiful and widespread group are not extremely rare in the Yorkshire Dogger, yet it would seem that none were available, when Phillips's early editions were published. It is somewhat singular that no notice should have been taken of these fossils in the third edition of the G.Y. (1875), notwithstanding their obvious and unmistakeable difference from the species just described (No. 67). In the Leckenby Collection and also at York they are known as "*Nerita bellulata*," Bean, MS.

None of the three Yorkshire forms figured answers exactly to Sowerby's type of *Monodonta lævigata*,[1] which measures as follows:—Height 12 mm., width 13 mm., spiral angle (approx.) 90°, ratio of body-whorl to entire shell 75: 100. Hence the type of the *M. lævigata* group is median between such extremes as *Monodonta acmon*, D'Orb., with a spiral angle of 65°, and the highly rotelliform section with an inconspicuous spire, which is represented by *Monodonta* (*Chrysostoma*) *ovulata*, H. and D., and perhaps yet further by *Crossostoma* of the Great Oolite. In the collections from the I.O. of the South of England the median form is well represented, but graduates into the rotelliform section; whilst the papilliform section is more sharply separated. Thus Mr. Tawney (Dundry Gasteropoda) recognized two species, viz. *Monodonta lævigata*, Sow., and *Monodonta acmon*, D'Orb.

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[1] Kindly lent to me by the Council of the Bristol Museum at the instance of Edward Wilson, Esq., F.G.S., the Curator.

It is well known that the bulk of these shells from the G.O. were classed by Morris and Lycett under *Monodonta Labadyei*, D'Arch., which belongs to the papilliform section. As far as I can see at present, no particular section can be predicated of any one horizon as being peculiar to it; but in each district of the Lower Oolites, and possibly higher up in the Jurassic system, some one or more of these sections will be found to prevail, but often with a local modification, which it would be difficult either to describe or depict, but which at the same time is recognizable. Such varieties may be regarded as races. Hence, perhaps, there is more variation laterally than vertically.

If people please to amuse themselves by giving specific names not only to the sections but also to the races which make up the group of *Monodonta lævigata*, well and good; but such "species" are not of equal value, seeing that they frequently represent differences which are extremely small in amount.

Description.—var. BELLULATA, Bean.—Specimen from the Dogger (zone 1), Peak (Blue Wyke). York Museum. Figs. 4, 4*a*, 4*b*.

Height	13·5 millimètres.
Width	14 ,,
Spiral angle	80°.
Ratio of body-whorl to entire shell	68 : 100.

Shell small, turbinate, not umbilicated. Whorls four or five, which increase under a regular angle, are moderately tumid, and separated by a well-defined, but not wide, suture. Body-whorl relatively large, tumid, with a very slight flattening of the posterior region. The entire shell is perfectly devoid of ornament, except lines of growth which are numerous and very fine. Aperture tolerably wide and nearly circular; columella thick and strongly toothed anteriorly.

Relations and Distribution.—This variety belongs to the papilliform section, represented in the Great Oolite by *Monodonta Labadyei*, D'Arch., and in the Callovian of Montrueil-Bellay by *Monodonta papilla*, Héb. et Desl. How far these three actually differ from each other it would be difficult to say, without having specimens of each side by side. It is the only section of the group, which is found in any quantity in the Yorkshire Dogger, though by no means common.

Description of another variety, B.—From the same horizon and locality. York Museum. Figs. 5 and 5*a*.

Height	9 millimètres.
Width	10 ,,
Spiral angle	irregular.
Ratio of body-whorl to entire shell	75 : 100.

This variety, which is similar to forms from other parts of England, is characterized by a great irregularity in the development of the whorls. The penultimate exhibits a remarkable bulge anteriorly, whilst the posterior region is considerably flattened. This variety probably occurs wherever the group is abundant. It is very rare in the Dogger.

Description of another variety near to *M. ovulata*, H. and D. From the same horizon and locality. Leckenby Coll. Figs. 6 & 6*a*.

Height	7·5 millimètres.
Width	10 „
Spiral angle	112°.
Ratio of body-whorl to entire shell	86 : 100.

Shell small, transversely ovate, depressed, not umbilicated. The spire is few-whorled and bears but a small proportion to the body-whorl, which is slightly flattened in its upper part, and extremely swollen anteriorly. Suture almost invisible, whorls extremely smooth. Aperture transversely (to the axis) ovate, columella short, thick and toothed anteriorly.

Relations and Distribution.—This is the most rotelliform of the *M. lævigata* group in the Yorkshire Dogger, and is to a certain extent the representative of *Monodonta ovulata*, Héb. et Desl. The typical *M. lævigata* lies between the two extremes shown in Figures 4 and 6. Extremely rare in the Yorkshire Dogger.

As regards the Relations and Distribution of the *M. lævigata* group generally, this subject was partly discussed under the heading "Bibliography." It might be hazardous to speculate how nearly some of the small smooth *Turbos*, not unfrequent in the Lias, are related to our *Turbo* (*Monodonta*) *lævigatus* group. This will require further investigation. As regards distribution in the Lower Oolites, we find all three sections recognized by Laube from the Brown Jura of Balin, though his identifications are not absolutely correct. By this author the group is referred to *Chrysostoma*, Swainson, classed by Gray with the rotelliform Trochids. Not noticed by Brauns in the Middle Jura of N. W. Germany. In the Yorkshire Oolites we do not find any shells of this kind between the Dogger and the Coral Rag, where three species were recognized (see "Corallian Gasteropoda," Geol. Mag. 1881, p. 53), in many respects analogous to the three sections of *Turbo lævigatus*.

69.—TURBO (DELPHINULA) FUNICULATUS, Phillips, 1829. VARIETIES.

Plate II. Figs. 7 and 8.

See "Corallian Gasteropoda," (GEOL. MAG. 1881, p. 54.)

Compare also

Turbo Hamptonensis, Morris and Lycett, Gt. Ool. Moll. p. 64, pl. ix. fig. 30.
Turbo Davoustii, D'Orbigny, Terr. Jurass. p. 344, pl. 331, figs. 7–10.

Bibliography, etc.—The type is, of course, a Corallian fossil not uncommon in the Coral Rag of Yorkshire. The fossils now under consideration are representative rather than identical forms; though, after all, the principal difference is probably due to the more exuberant development of the Coral Rag fossil and partly to difference of status. As these shells are extremely rare in the Lower Oolites of Yorkshire, the present classification is only provisional, and the same may be said of the suggested comparisons.[1]

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[1] In both figures, but especially in Figure 8, the granulations are made too small and too circular. There are indications that these nodes were more imbricated.

Descriptions.—Dogger Variety.—Specimen from the Dogger (zone 1), Peak (Blue Wyke). Leckenby Collection. Figure 7.

Approximate	Height	6·5 millimètres.
	Width	6·25 ,,
	Spiral angle	78°.

A small turbinate shell, highly ornamented. Spire few-whorled (much eroded in the specimen), and apparently about ⅓rd the height of the entire shell. Body-whorl large, sutures wide. The ornamentation is rich, consisting of well-cut spirals strongly tuberculated; the uppermost row of tubercles recedes, and was probably rather imbricated. Other indications are wanting.

Cornbrash Variety.—Specimen from the Cornbrash (zone 4), Scarborough. Leckenby Collection. Figure 8.

Approximate	Height	12 millimètres.
	Width	11·25 ,,
	Spiral angle	80°.

About twice the size of the Dogger variety, but too imperfect and too much involved in matrix for accurate description. The system of the tuberculation is proportionately enlarged, the tubercles being exceedingly coarse and spirally elongate. The specimen having been much eroded, these tubercles have a sort of polished appearance, though it is not improbable that they were originally imbricated. Suture wide.

Relations and Distribution.—But little more can be said on these points. The gaping suture and the probable imbrication of the nodes make it almost certain that these forms, small and battered though they be, belong to the group of *Delphinulæ*, of which *Turbo* (*D.*) *funiculatus*, Phil., may be regarded as the type. Each specimen is unique in its horizon for Yorkshire, and this is an additional reason for not attempting any new names. Specimens similar to, if not identical with, the Dogger variety, may be noted occasionally from the Inferior Oolite of other parts of England.

70.—Turbo (Delphinula) granatus, sp. n. Plate II. Figs. 9–12.

Delphinula granata, Bean, MS.
Solarium granatum, Bean, MS.

Descriptions.—Section A.—Shell depressed, bicarination of body-whorl indistinct.

Specimen from the Dogger (zone 1), Peak (Blue Wyke). Leckenby Collection. Figs. 9, 9*a*.

Height	5·5 millimètres.
Width	6·5 ,,
Spiral angle	120°.
Ratio of body-whorl to entire shell	85 : 100.

Shell small, turbinate, depressed, umbilicated. Whorls angular and step-like; those of the spire about 4 in number; suture rather close. The apical whorls are nearly smooth, but the antepenult exhibits a fine granulated carina towards the base, whilst the rest of the shell is marked by fine spiral granulations with larger granulations on the carinæ. Body-whorl very large in proportion and angular; close to the suture is a double spiral ridge slightly tuberculated, the remainder of the flat area being marked by finely-granulated spirals. The widest part of the shell is marked by a slight carina with larger granulations, below which are other slight keels: base granulated.

This specimen represents a young individual: the ornaments are exceptionally well preserved.

Another specimen.—Same horizon and locality. Bean Collection, British Museum. Figs. 10 and 10*a*.

Height	6·5	millimètres.
Width	7·75	,,
Spiral angle	110°.	

This probably represents a more mature individual than the preceding. The body-whorl is slightly bicarinate, the upper keel being somewhat the stronger. The base of the shell is ornamented by fine granulated spirals terminating in a spiral of larger tuberculations, which fringes a moderately wide and deep umbilicus. The aperture is slightly pentagonal, and fairly large.

Another specimen.—Same horizon and locality. York Museum. Figs. 11, 11*a*, and 11*b*.

Height	11·5	millimètres.
Width	13·25	,,
Spiral angle	Irregular.	

A fine example of the mature shell. It consists of five whorls: the apical ones are free from granulations, but with the usual carinæ: penult sufficiently uncovered to show the lower carina. Suture rather more open than in the smaller specimens. Ornaments of the body-whorl rather coarser than in the smaller specimens. Upper carina bigranulate: lower carina scarcely distinguishable. The tuberculated spiral which fringes the umbilicus very conspicuous (11*b*). Aperture nearly circular, with the pillar lip slightly produced.

Section B.—Shell sub-conical: bicarination of body-whorl distinct.

Specimen from the same horizon and locality. My Collection. Not figured.

Height	12·5	millimètres.
Width	12·5	,,
Spiral angle (about)	85°.	

The points in which this form differs from those described under Section A. are (1) the more conical outline of the spire, which is almost acute; (2) the strong bicarination of the body-whorl; (3) the coarser tuberculation of the spiral surrounding the umbilicus; and (4) the spiral angle of lower value. This specimen has a sort of superficial resemblance to "*Trochus*" *biserius*.

Another specimen.—Same horizon and locality. Bean Collection, British Museum. Fig. 12.

Trochiform like the last, the whorls of the spire are devoid of granulations, though the keels are well marked. The ornamentation of the upper part of the body-whorl is peculiar, the spirally granulate character being masked by an axial or transverse system. Owing to the matrix, it is not easy to say if the lower keel is developed.

This is probably an aged shell, or it may have suffered during the process of mineralization.

Relations and Distribution.—It will be gathered from a comparison of the descriptions under Sections A and B, that there exists a depressed and irregular form (A), and a sub-conical and more regular form (B); each of which has hitherto been referred to *Turbo* (*Delphinula*) *granatus*, and had best remain so for the present. The young specimens of Section A have a very wide spiral angle. It is just one of those groups that easily passes into something else, which is nearly, but not quite the same. It may, I think, be seen in collections from the Lincolnshire Limestone, but south of this I have not at present traced it.

The analogous or representative species in the rich univalve beds of the I.O. of Dorset-Somerset must be sought in *Turbo Shaleri*, Tawney (Dundry Gasteropoda, p. 23, pl. 2, fig. 3). In *Turbo Shaleri*, which may well be regarded as belonging to the subgenus *Delphinula*, the shell is somewhat more depressed than in our section A.; and the whorls, especially the body-whorls, are more angular and possessed of more prominent and better defined carinæ. In *T. Shaleri* also the umbilicus is wider, and bounded by a spiral of large tubercles, few in number, rather than by the small and numerous granules which surround the umbilicus in *D. granata* (see Fig. 11*b*).

Not found in Yorkshire anywhere but in the Dogger of the Peak. Nothing of the kind is quoted by Brauns from N.W. Germany. Amongst the numerous small species of *Turbo* figured and described by D'Orbigny, we can scarcely doubt that some must be pretty near to *Turbo* (*Delphinula*) *granatus*.

71.—Turbo ? species. Plate II. Fig. 13.

Description.—Specimen from the Dogger (zone 1), Peak (Blue Wyke). Bean Collection, British Museum.

Approximate	Height	6·75 millimètres.
	Width	5·50 ,,
	Spiral angle	75°.

Shell small, trochiform, higher than wide. Spire subacute, and composed of about five whorls, which are almost regular in their increase; apical whorls nearly smooth; anterior whorls angular, spirally granulate, and ornamented by carinæ with larger granulations, which vary somewhat in each whorl, but may be described as follows: (1) a fringe of beady granules close to the suture; (2) a double row of beady granulations at the angle of the whorl, the upper row being the strongest and occupying the salience of the whorl; (3) the body-whorl developes an anterior row of beady granulations in addition to the preceding. Suture moderately close. Base spirally granulate. Other indications wanting.

Relations and Distribution.—The granulated character of the ornaments and to some extent their arrangement serve to connect this shell with section B. of *Delphinula granata*. On the whole, however, its truly conical *outline*, closer suture, and the double row of granulations make it difficult to believe that this can represent the young form of section B.

Hence it may be fairly regarded as a distinct species, which I have not yet succeeded in tracing elsewhere. Bearing in mind that the specimen is unique, and that the aperture cannot be seen, it would be premature to make a new species; but should a name be required, I would suggest that it be known as *Turbo gemmuliferus.*

72.—TURBO? species. Pl. II. Fig. 14.

Description.—Specimen from the Dogger (zone 1), Peak (Blue Wyke). Bean Collection, British Museum.

Approximate	Height	6·25 millimètres.
	Width	6·5 ,,
	Spiral angle	90°.

Shell small, subdepressed, step-like. The spire consists of about 4 whorls, the apical ones being smooth and inflated. The penult is angular, and partially bicarinate anteriorly, the upper keel marking the chief salience: traces of extremely fine spiral ornamentation. Body-whorl large, both in height and width, relatively to the spire, and strongly angular; three well-marked carinæ of nearly equal strength occupy the median prominence, the upper keel being slightly double: fine spiral lines without granulation ornament the whole of the body-whorl, including the base. Suture moderately close. Other indications wanting.

Relations and Distribution.—Less depressed, and with a more symmetrical spire than *Delphinula granata,* this form is further differentiated by the non-granulated character of the keels and spiral lines. At present I have failed to trace the exact counterpart elsewhere. Bearing in mind the apparently local character of certain forms, and the fact of this specimen being unique, it would be premature to recognize it as a named species. Should it be found to occur more plentifully, I would suggest the name of *Turbo* (*Delphinula*) *lævior.*

Genus TROCHUS, Linnæus, 1758.

The three zones of the Inferior Oolite in Yorkshire are extremely poor in shells referable to this genus. I have already expressed a belief that "*Trochus*" *bisertus,* Phill., belongs to the so-called *Littorinæ*: and even if this group is ultimately restored to the *Turbinidæ, T. bisertus* cannot be regarded as a *Trochus.*

In *Trochus monilitectus,* Phil., we possess a well-marked and characteristic *Trochus,* almost the only one hitherto noted from any portion of the I. O. of Yorkshire. The Lias of Yorkshire, according to Tate and Blake, has yielded three species of *Trochus,* only one of which is at all plentiful. Hence we are prepared to have the genus poorly represented in the Dogger.

73.—TROCHUS, near to DIMIDIATUS, Sowerby, 1818. Pl. II. Fig. 15.

1818. *Trochus dimidiatus,* Sowerby. Min. Conch. pl. 181, fig. 4.

Bibliography.—Sowerby described his species from a single specimen found at Little Sodbury. It is just possible that some of D'Orbigny's species from the I. O. are synonyms.

Description.—Specimen from the Dogger Sands (lower part of zone 1), Blue Wyke. Leckenby Collection.

The specimen is too much involved in matrix for close description. The spire consists of about four whorls, which increase under a regular angle, the apical ones being smooth and inflated. The penult shows traces of a strong carina: the body-whorl, which is relatively large, has two keels, of which the lower represents the margin of the base. Shell plain.

Relations and *Distribution.*—This small fossil is so near to Sowerby's species that it would be unsafe to separate them. The specimen figured is the only one known to have been found in the I. O. of Yorkshire.

EXPLANATION OF PLATE II.

Fig. 1. *Neritopsis lævigata*, Phil. Variety A. Dogger, Blue Wyke Leckenby Collection. Back view. × 1½.
„ 2. *Ib.* Variety A. Dogger, Blue Wyke. Jermyn Street Museum. Front view. × 1½.
„ 3, 3*a*. *Ib.* Variety B. Dogger, Blue Wyke. York Museum. Back and front views. × 1½.
„ 4, 4*a*, 4*b*. *Turbo* (*Monodonta*) *lævigatus*, Sow., var. *bellulatus*, Bean. Dogger, Blue Wyke. York Museum. Back, front, and basal views. × 1½.
„ 5, 5*a*. *Ib.* Variety B. Dogger, Blue Wyke. York Museum. Back and front views. × 1½.
„ 6, 6*a*. *Ib.* var. near to *ovulata*, H. & D. Dogger, Blue Wyke. Leckenby Collection. Back and front views. × 1½.
„ 7. *Turbo* (*Delphinula*), cf. *funiculatus*, Phil. Dogger Variety. Leckenby Collection. Back view. × 1½.
„ 8. *Ib.* Cornbrash Variety. Leckenby Collection. Back view. × 1½.
„ 9, 9*a*. *Turbo* (*Delphinula*) *granatus*, Bean MS. Young specimen. Dogger, Blue Wyke. Leckenby Collection. Apical and back views. × 1½.
„ 10, 10*a*. *Ib.* Intermediate in size. Dogger, Blue Wyke. Bean Collection, British Museum. Front and back views. × 1½.
„ 11, 11*a*, 11*b*. *Ib.* Mature specimen. Dogger, Blue Wyke. York Museum. Back, front, and basal views. × 1½.
„ 12. *Ib.* Section B. Probably an old or worn specimen. Dogger, Blue Wyke. Bean Collection, British Museum.
„ 13. *Turbo* (*Delphinula*), species. Dogger, Blue Wyke. Bean Collection, British Museum. Back view. × 1½.
„ 14. *Turbo* (*Delphinula*), species Dogger, Blue Wyke. Bean Collection, British Museum. Back view. × 1½.
„ 15. *Trochus*, cf. *dimidiatus*, Sow. Dogger Sands, Blue Wyke. Leckenby Collection. Back view. × 1½.

(*To be continued.*)

II.—Geological Nomenclature.

By Prof. F. W. Hutton F.G.S.

I SHOULD be much obliged if you would allow me to make a few remarks on the subject of Geological Nomenclature. Certain points connected with nomenclature are forced on the attention of a geologist living at the antipodes of Europe which are not likely to attract the notice of one who is working in, or near, the region from which the standard table of rock-systems has been drawn up; and this must be my excuse for coming forward in a matter which has already been so much and so well discussed.

I do not object to the work done by the International Congress at Bologna. On the contrary, I think that the names "System," "Series," and "Stage," with their chronological equivalents, can be advantageously employed by British geologists in all parts of the world; and I quite agree that the term "formation" should be used only with reference to the mode of origin of a rock. The term "group" seems to be unnecessary, as we can always speak of the Palæozoic or the Mesozoic rocks of a country with all the accuracy required when using such wide terms; while we cannot always do the same with sufficient accuracy when referring to rocks belonging to the shorter periods or epochs. For example, I can speak of the Mesozoic rocks of New Zealand, because the term is wide and makes no pretension to accuracy. But I cannot speak of the Jurassic or of the Cretaceous rocks of New Zealand with any approach to accuracy, although our present unmethodical nomenclature often compels me to do so; and it is on the question of correlating systems in different parts of the world that I wish to lay my views before your readers.

It is generally allowed that although deposition has been going on continuously in some part or other of the earth, a complete series of rocks does not exist in any one geological region: and it is also allowed that the breaks in the sequence in different regions are not contemporaneous. From this it follows that the rock-systems of any one geological region cannot possibly be the chronological equivalents of the rock-systems of other regions. Chronological overlappings must constantly occur, and consequently there is no single region in which the rock-systems can be taken as supplying a nomenclature applicable to the whole world. Further, in consequence of overlapping, no table of rock-systems, collected from different parts of the world, can be compiled which will show a simple sequence. It is therefore quite impossible to squeeze the rock-systems of other regions into those found in the European area. They will not fit.

This being so, it is evident that, if geological nomenclature is to be fairly accurate, each geological region must have a separate set of systems distinguished by different names. This is allowed by Dr. A. Geikie.[1] But in order that these regional systems may be connected together, it is necessary that geological time should be divided into a set of divisions quite irrespective of any particular region: and the systems could then be referred to this chronological scale with greater and greater accuracy as our knowledge of the palæontology of each region increased.

Geological regions with separate systems would be established wherever it was thought to be necessary, but in time some might amalgamate, or partly amalgamate. For example, there is in New Zealand a physically connected system of rocks which I have called the "Hokanui system." Future investigation may prove that this is the equivalent of the "Newer Carbonaceous System" of Australia, and in time both may be shown to be equivalents of the "Gondwana System" of India. If so, the earlier name would stand for the Regional System and the others would become synonyms. But it would not therefore follow that the Cainozoic Systems of India and New Zealand were equivalents; each system would retain its own name until it was proved to be the equivalent of some other. Some systems would be quite local, others would be widely spread. Exactly the same method would be employed with the series composing a system. Each would retain its own name until two or more were united by palæontological evidence. Of course differences of opinion would arise as to whether two series, or two systems, should or should not be united. This is unavoidable in any case. It is the same difficulty which naturalists have to deal with in making species and genera. But it is no more, and probably a consensus of opinion would soon settle each point.

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[1] Text-Book of Geology, p. 635.

It may be objected that a great number of names would have to be introduced, many of which would in time become obsolete. This is true; but on the other hand, applying the names of the rock-systems of Europe to the systems in other parts of the world must always be very inaccurate, and may lead to serious error. It is better to multiply names if it insures accuracy, than to insure inaccuracy by making a few names cover everything. An illustration will render the comparative merits of the two methods clearer. Suppose, then, the existence of a rock-system in Chili which in reality covered in time part of the Jurassic and part of the Cretaceous period. At first, when the knowledge of its fossils was slight, there might be a difference of opinion as to its age. By the one method some geologists would apply the name Jurassic, others Cretaceous to it, so that confusion might easily arise. But when its true age came to be known, a compound name, such as Cretaceo-Jurassic, would have to be invented, and even then, this cumbrous name would not be accurate, as the system would not cover the whole of these periods. By the other method the system would at once be called (say) the 'Talca system,' and under this name it would always remain, unless shown to be the exact equivalent of some other system. Its true age would at first be disputed, but no confusion could arise, as no chronological name would be applied to it. Ultimately this point would be settled and the system referred to its proper place in the universal scale. The name 'Talca system' would also be accurate, as it would include those particular rocks only, neither more nor less.

It might also be objected that under the system here advocated it would not be possible to colour geological maps uniformly; but this objection has no weight. It is impossible, in any case, to colour all geological maps uniformly, because the regional systems overlap in time. It would be no advantage to call a system Silurian, in order that it might be so coloured, when we know that it cannot be the equivalent of that European system. In the method I advocate the colours would represent the chronological divisions of the universal scale, and each system would be coloured as if it belonged to that chronological division which most nearly represented it.

The regional systems and series would, of course, have geographical names, but the names of the chronological divisions should not be geographical, as they would be made for palæontological reasons. We have very good chronological names for the four great eras, and the names of the Cainozoic periods are well adapted for introduction into the chronological scale as divisions. What is wanted are new names for the divisions of the Mesozoic and Palæozoic eras. The Archæan need not be divided until some means of correlating the systems has been discovered. These divisions would form a complete sequence, and it would be as impossible to intercalate a new division as it would be to put in a new era between the Palæozoic and Mesozoic. But as our knowledge of palæontology advanced, it might be found advisable to make subdivisions in some cases, and for this reason the names of the divisions should not be Upper, Middle, and Lower.

One word more as to what I understand by systems. These would be separated by well-marked unconformities—physical or palæontological—over the whole or the greater part of the region, and would show important geological changes in the region. Consequently they would have very unequal chronological values. In one region there might be only one Cainozoic system, while in another region it might be necessary to establish three or four systems. They would therefore bear no relation to the chronological divisions, which themselves would represent, as they do now, very unequal .portions of time. The duration of the divisions would depend on the rate of biological change. The duration of the systems would depend on the frequency of important changes in the physical geography of each geological region. Mr. Blanford says that "the principal divisions should be as nearly as possible of equal value,"[1] and no doubt this is theoretically true as regards the chronological divisions, but it would be difficult to carry out in practice, as our geological chronometer—biological change—has been going faster and faster.

Of course I do not pretend that there is anything new in these remarks. Geologists are applying the principle in all parts of the world. Even in England, as soon as Archæan rocks were discovered, new names were given to them, because it was seen to be impossible to correlate them with the previously-established Archæan systems in Canada. All that I advocate is that the principle should be carried out methodically by putting the European rock-systems on the same footing as the rock-systems of other parts of the world, and by drawing up a chronological scale to which all systems might be referred.

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[1] GEOLOGICAL MAGAZINE, July, 1884, p. 319.

III.—NOTE ON THREE GENERA OF FOSSIL ARTIODACTYLA, WITH DESCRIPTION OF A NEW SPECIES.

By R. LYDEKKER, B.A., F.G.S., F.Z.S.

CÆNOTHERIUM FILHOLI, *sp. nov. nobis.*

From the Quercy Phosphorites.

IN his memoir on the Vertebrates of the Quercy Phosphorites, Dr. Filhol has described two species which he refers to the genus *Cænotherium*, viz. *C. commune*[1] and *C. elongatum*.[2] Of the former only one ramus of the mandible is figured, and it is referred to a varietal form under the name of *procommune*: the latter, which is a small form, is known by the cranium and mandible. Both species have no diastema in the dental series. In addition to these, two small species are referred to the genus *Plesiomeryx*, under the names of *P. cadurcensis*[3] and *P. quinquedentatus*,[4] the latter being known only by the mandible; these forms are distinguished from the true *Cænotherium* by the presence of a diastema between the earlier premolars.

From the Lower Miocene of Cournon (Puy-de-Dôme) and St. Gérand-le-Puy (Allier) Dr. Filhol recognizes three species of *Cænotherium* proper, viz. *C. commune*,[5] *C. laticurvatum*,[6] and *C. Geoffroyi*;[7] and one species of *Plesiomeryx*, viz. *P. gracilis*.[8] The two latter are of very small size; and *C. laticurvatum* is the largest of all. In a later memoir[9] the same writer describes a lower jaw from the Lower Miocene of Ronzon, near Puy-en-Velay, which is also referred to *P. gracilis*, although it presents no diastema. This specimen is the type of Aymard's ill-defined *Zooligus Picteti* (= *C. Picteti*, Gervais); and on its evidence Dr. Filhol says that no distinction derived from dental characters can be drawn between *Cænotherium* and *Plesiomeryx*; although the latter is retained as a sub-genus marked by certain cranial characters. The present writer prefers to altogether abolish the latter term. From the Upper Eocene of Mouillac, France, Dr. Filhol[10] has more recently described a fragment of the maxilla of an allied form containing the last five teeth under the name of *Mouillactherium elegans*. The specimen has not been figured; but it is described as differing from typical species of *Cænotherium* by having a larger and more forwardly placed inner cusp to $\underline{\text{pm. 3}}$, by the absence of the third cusp on the hinder lobe of $\underline{\text{m. 3}}$, and by the presence of a diastema between $\underline{\text{pm. 2}}$ and $\underline{\text{pm. 3}}$. The species is of small size, the length of the space occupied by the three true molars being 0·011. The generic distinctness of this form may perhaps be doubted. The following table indicates the chief characters of the eight species mentioned above.

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[1] Ann. Sci. Géol. vol. viii. art. 1, p. 212, pl. xii. pl. xii. figs. 269–70 (1877).

[2] *Ibid.* p. 212, pl. xii. figs. 275-8.

[3] *Ibid.* p. 205, pl. xii. figs. 271-4.

[4] *Ibid.* p. 430, pl. xix figs. 314-16.

[5] *Ibid.* vol. x. art. 3, p. 213, pl. xxviii.

[6] *Ibid.* p. 226. pl. xxix.

[7] *Ibid.* p. 240.

[8] *Ibid.* vol. xi. pl. 1, fig. 13 (1881).

[9] *Ibid.* vol. xii. art 3, pp. 77–84, pl. xi. pp. 53-9 (1882). From specimens in the British Museum the writer is inclined to think that *C. cadurcense* and *C. gracile* may be identical. Filhol regards them as very closely related.

[10] Ann. Soc. Sci. *Phys. Nat. Toulouse*, 1882, pp. 128-30.

Cænotherium, 3 cusps on the hinder lobe of $\underline{\text{m. 3}}$.
No diastema.

1. *Cænotherium laticurvatum*, St. Gérand-le-Puy.
2. *Cænotherium commune*, Cournon, and Quercy Phosphorites.
3. *Cænotherium Geoffroyi*, St. Gérand-le-Puy.
4. *Cænotherium elongatum*, Quercy Phosphorites.

A diastema usually present between pm. 1 and pm. 2 in both jaws (*maxilla unknown* in No. 6).

5. *Cænotherium cadurcense*, Quercy Phosphorites.
6. *Cænotherium gracile*, St. Gérand-le-Puy, and Ronzon.

A diastema between $\overline{\text{pm. 2}}$ and $\overline{\text{pm. 3}}$ (*maxilla unknown*).

7. *Cænotherium quinquedentatum*, Quercy Phosphorites.

Mouillactherium, 2 cusps on the hinder lobe of $\underline{\text{m. 3}}$.
A diastema between $\underline{\text{pm. 2}}$ and $\underline{\text{pm. 3}}$ (lower jaw unknown).

8. *Mouillactherinm elegans*, Quercy Phosphorites.

It will be observed that Nos. 7 and 8 agree in the position of the diastema, and, although the latter is a larger species, their generic identity may perhaps be indicated by this character.

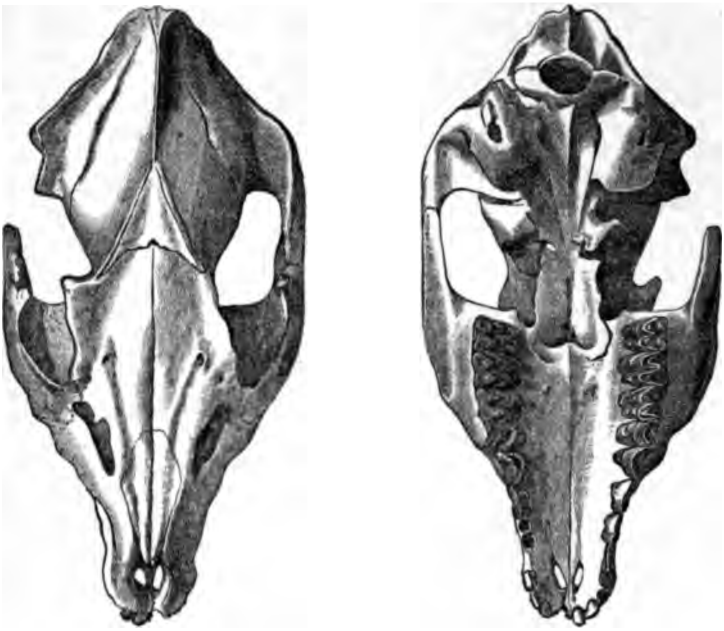

FIG. 1. *Cænotherium Filholi*, Lyd. Upper and lower views of the cranium; from the Upper Eocene of Caylux. ¼. (B. M. No. 1399).

Among a collection of fossils from the Quercy Phosphorites recently acquired by the British Museum, are two skulls of a species belonging to the present group, remarkable for their fine preservation, and on this account alone worthy of description. Both specimens are from Caylux (Tarn et Garonne). The first, which is represented in Figure 1, consists of the cranium only, and is almost as perfect as a recent skull. The only loss which it has sustained is a portion of the right zygomatic arch; part of the posterior border of the left orbit; the right outer incisor and canine; and the left inner incisor and the first premolar. The cheek-teeth belong to the permanent series, and are but slightly worn. The extreme length of the upper surface of the skull is 0·081, which is practically the same as in the type of *C. laticurvatum* (0·0815), although some specimens of the latter (var. *metopias*) are larger. The present specimen differs, however, from that species by the presence of a distinct diastema; which is situated between the canine and $\underline{\text{pm. 1}}$, instead of between the earlier premolars,[1] as in the so-called *Plesiomeryx*. In this respect, therefore, the skull under consideration differs from the first seven species named above. It differs, moreover, in another very important point. In *C. laticurvatum* (which as already said is the only species which agrees in size with the present specimen), the nasals are long, narrow, convex bones, wider in front than behind, terminating anteriorly in a notch, and having a depression at their junction with the frontals. In the present specimen the nasals are very short, quite flat, and the two together form an oval, terminating anteriorly in an acute point. There is no depression in the frontal at the junction of these bones, neither are the frontal sulci as conspicuous as in *C. laticurvatum*. In all the other species of which the cranium is known, the nasals are long and terminate anteriorly in a notch. *C. elongatum* (in which there is no diastema) and *C. cadurcense* agree with the present specimen in having indistinct frontal sulci, and no depression at the root of the nasals. The present specimen agrees with the much smaller last-named species, and *C. commune*, in having the anterior border of the posterior nares situated on the line dividing $\underline{\text{m. 1}}$ and $\underline{\text{m. 2}}$. The figures of the crania of the above-mentioned species do not show the other cranial sutures. In the present specimen the premaxillæ extend upwards to articulate with the frontals. The lachrymal has a small facial, and a large orbital portion. The facial vacuity is narrow and long. The frontal portion of the cranium is flat; the sagittal crest well developed; and the profile much less arcuated than in *C. laticurvatum*. The squamosals extend high up on the temporal fossæ; and the auditory bullæ are of very large size. There is a minute inner cusp to $\underline{\text{pm. 2}}$, which seems wanting in other forms: the inner cusp of $\underline{\text{pm. 3}}$ is rather larger than in *C. laticurvatum*, and apparently comes near to *Mouillacitherium*. There is no diastema between any of the premolars, and the hind lobe of $\underline{\text{m. 3}}$ has three cusps.

The second specimen (Fig. 2) is a good deal crushed and broken, but is very important in having the mandible attached to it. This cranium has nasals similar to the last, a diastema between the canine and $\underline{\text{pm. 1}}$, and may, therefore, be referred to the same species as the last; its somewhat smaller size indicates that it probably belonged to a female. The lower dental series shows a diastema occurring between $\overline{\text{pm. 1}}$ and $\overline{\text{pm. 2}}$; as is usually the case in the species Nos. 5 and 6 in the foregoing list. The mandible of *C. cadurcense* is smaller than the present specimen; that of *C. quinquedentatum*[1] is still smaller; and the same may be said of *C. grucile.*[2] In those forms which have no diastema, the mandible of *C. laticurvatum*[3] has a much larger descending process at the angle; that of *C. commune*[4] is deeper posteriorly; and that of *C. elongatum*[5] has the inferior border in advance of the angle highly arcuated in place of nearly straight.

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[1] It is assumed that in *C. gracile* the diastema has the same position as in *C. cadurcense*.

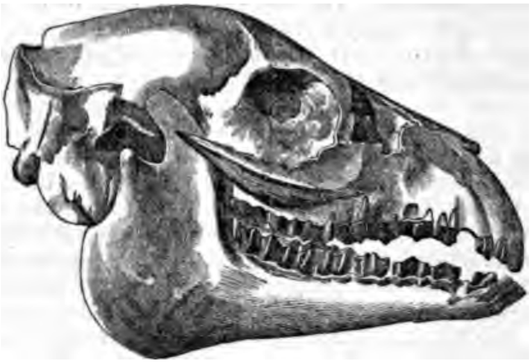

Fig. 2. ***Cænotherium Filholi***, Lyd. The right lateral aspect of the cranium and mandible, from the Upper Eocene of Caylux. $\frac{1}{1}$. (B. M., No. M. 1440).

The foregoing comparisons indicate the distinctness of the present from all the seven species of *Cænotherium* recognized by Dr. Filhol. A number of other species have indeed been named, but mostly on insufficient specimens. The so-called *C. Courtoisi*, Gervais,[6] is much smaller than the present specimen, and together with Piclet's *C. Benevieri* is referred by Kowalevsky (Phil. Trans., 1873, p. 25) to *Hyopotamus*. *C. collotarsum*[7] is founded on specimens which do not prove its distinctness from other forms. The part of the cranium of Meyer's *Microtherium* figured by Gervais in the "Zool. et Pal. Françaises" (2nd ed. pl. xxxiv. p. 7), seems to belong to *C. laticurvatum*. From *Mouillactherium elegans* the present form is distinguished by its superior size, by the absence of a diastema between $\underline{\text{pm. 2}}$ and $\underline{\text{pm. 3}}$, and by the presence of a third cusp on the hinder lobe of $\underline{\text{m. 3}}$; it seems, however, to be allied to that form by the large development of the inner cusp of $\underline{\text{pm. 3}}$.

Seeing, therefore, that the present form is markedly distinct from all those species of *Cænotherium* which are described upon sufficiently perfect specimens, and as it cannot be identified with any of the imperfectly known forms or with *Mouillactherium elegans*, it seems permissible to give it at least a provisional new specific name; and that of *Filholi* is proposed, in honour of the describer of so many of the Quercy vertebrates. The writer proposes to place the species in the type genus; but if the genus *Plesiomeryx* be maintained, it would seem necessary to form another genus for the present form, as the position of the diastema is different from that which occurs in the species of *Plesiomeryx* of which the skull is known, or in *Mouillactherium.*

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[1] Ann. Sci. Géol. vol. viii. pl. xix. figs. 314–6.

[2] *Ibid.* vol. xi. pl. i. fig. 3; vol. xii. pl. xi. fig. 58.

[3] *Ibid.* fig. 7. *Ibid.* vol. viii. pl. xii. figs. 269–70. [5] *Ibid.* fig. 276.

[6] Zool. et Pal. Franç. 2nd ed. p. 162. [7] *Ibid.*

The following table gives the dimensions of the skulls of *C. Filholi* and a typical skull of *C. laticurvatum.*

		C. Filholi.		*C. laticurvatum.*
		No. $\frac{M}{1399}$	No. $\frac{M}{1400}$	
Cranium.—	Extreme length superiorly	0·081	0·073	0·0815
	,, inferiorly	0·067	0·064	0·070
	Length of series of cheek-teeth	0·032	0·031	0·037
	,, true molars	0·0144	0·0143	0·0175
	Width of palate at m. 3	0·014		0·015
	Length of nasals	0·019	0·0175	0·024
	Greatest width of do.	0·008	0·0075	0·006
	Height of occiput	0·015		0·016
	Extreme height of cranium	0·033		0·033
	Vertical diameter of orbit	0·014	0·013	0·015
	Length of diastema	0·0037	0·003	
Mandible.—	Extreme length		0·056	0·067
	,, height		0·037	0·043
	Length of dental series		0·039	0·042
	,, last six teeth		0·030	0·034
	Height at p.m. 2		0·007	0·005
	,, m. 3		0·013	0·017
	Length of diastema		0·0026	

CÆNOTHERIUM sp. (? nov.)

From the Quercy Phosphorites.

The anterior portion of a third cranium from Caylux, which is figured from the palatal aspect in woodcut Fig. 3, apparently indicates a new variety or species. With the exception of the third incisor, the specimen shows the complete dentition on the left side; and also the orbit and the anterior root of the left zygomatic arch. The premaxilla and frontal of the same side also remain; but the nasals have disappeared, although a cast of their inner surface remains. The dentition is of the type of the last species; that is, there is a diastema between the canine and $\underline{\text{pm. 1}}$; and in no other part. This character at once distinguishes the specimen from the first four species of *Cænotherium* mentioned in the list given above: and the specimen is of considerably larger size than either of the last three species in that list. From *C. Filholi* it is distinguished by the much smaller space occupied by the cheek-teeth; and also by the circumstance that the nasals (as shown by their cast) are of the elongated type of *C. commune*; terminating anteriorly in a notch, and with their lateral borders diverging

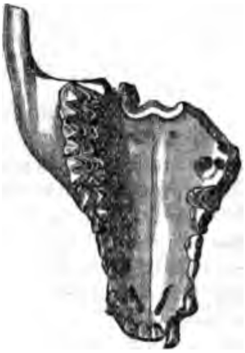

FIG. 3. *Cænotherium*, sp. The palatal portion of the cranium: from the Upper Eocene of Caylux. $\frac{1}{1}$. (No. M. 1401.)

regularly outwards from their roots. The frontals seem to have been flat, without any depression at the junction with the nasals; and the premaxillæ extend upwards to articulate with the frontals. The form of the palate is very like that of *C. commune*; but the interval between m. 1 and the incisors is much less, and the incisors and canine are considerably larger.

In Fig. 4 there is represented the left ramus of the mandible, imperfect posteriorly, of a *Cænotherium*, from Caylux, which from its size and general characters may very probably be referred to the same species as the cranium just described. It is of considerably smaller size than the mandible of *C. Filholi*, but agrees in having a distinct diastema between $\overline{\text{pm. 1}}$ and $\overline{\text{pm. 2}}$. It is much larger than the mandible of *C. quinquedentatum* and *C. gracile*; and is also larger than that of *C. cadurcense*, in which the length of the space occupied by the last six cheek-teeth is only 0·0215.

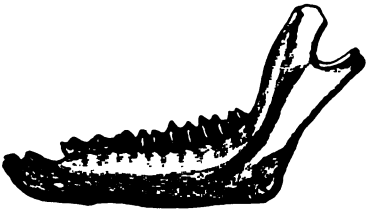
Fig. 4. *Cænotherium*, sp. The left ramus of the mandible, imperfect posteriorly: from the Upper Eocene of Caylux. $\frac{1}{1}$. (B.M. No. M. 1401, a.)

The following are the dimensions of the cranium and mandible.

Cranium.—	Length of series of cheek-teeth	0·028
	,, ,, true molars	0·013
	Greatest width of nasals (anteriorly)	0·0052
	Vertical diameter of orbit	0·0125
	Length of diastema	0·002
Mandible.—	Extreme length	0·044
	,, height	0·027
	Length of dental series	0·033
	,, last six teeth	0·0248
	Height at pm. 2	0·0065
	,, m. 3	0·083
	Length of diastema	0·0021

From the foregoing comparisons it is quite evident that the cranium mentioned above is specifically distinct from *C. Filholi*; and it cannot be identified with *Mouillactherium* (from which it is distinguished by the two structural characters noted in the case of *C. Filholi*); or with the so-called *C. Courtoisi*, or *C. collotarsum*. It differs from all the seven species of *Cænotherium* recognized by Dr. Filhol from the Cournon, St. Gérand-le-Puy, and Quercy beds; but its resemblance to *C. commune* is sufficiently close to suggest the question whether it might not be the male form of that species. Against this view there is, in the first place, the circumstance that the palate is shorter than in *C. commune*; and in the second place, that among the very numerous crania of that species from Cournon none present the characters of the present form; but are all (where the teeth are fully developed) characterized by the total absence of a diastema in both jaws.

The case of the two varieties of *C. gracile* noticed above indicates, however, the need of caution in founding new species merely on the presence or absence of a diastema. Under these circumstances it appears desirable to await additional specimens before deciding whether the present specimens should be regarded as a new species, or merely as a well-marked variety. The name *Bravardi*, either as a specific, or a varietal one, may eventually be appropriately applied to this form.

ANTHRACOTHERIUM GRESSLYI (H. v. Meyer).

From the Headon beds of Hordwell.

In the year 1846, the late Hermann von Meyer (Neues Jahrbuch, p. 471) briefly described some mammalian teeth from the siderolithes of Egerkingen, Canton Solothurn, Switzerland, under the name of *Tapinodon Gresslyi*. In 1862 Professor Rütimeyer (Denkschr. schw. nat. Ges., vol. xix. art. 3, p. 70, pl. v. figs. 64-67), described and figured the three associated upper true molars, and the second and third lower true molars, of a small mammal from the same deposits, which he identified with Meyer's *Tapinodon Gresslyi*, but referred to the genus *Hyopotamus*, under the name of *H. Gresslyi* (Myr.).

Among the collection made by the late Marchioness of Hastings from the Headon beds of Hordwell, Hampshire, and now in the British Museum, there is the cranium (No. 29,851), and a mandible (No. 29,713), probably belonging to the same individul, and certainly to the same species, of a small mammal, the teeth of which agree precisely with those figured by Rütimeyer under the name of *Hyopotamus Gresslyi*. The Hordwell specimens may, therefore, be referred to that species.

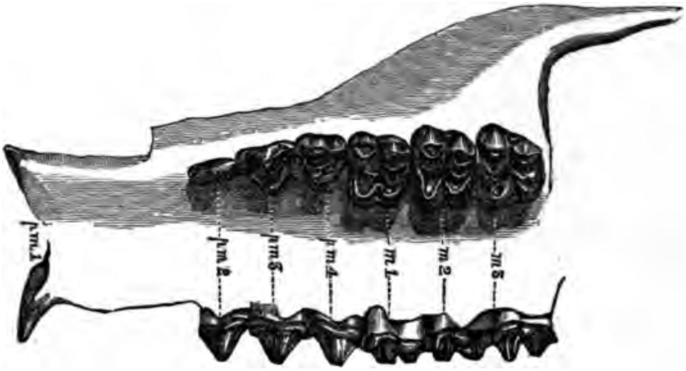

FIG. 5. *Anthracotherium Gresslyi* (Meyer). The left half of the palate and the upper cheek-dentition; from the upper Eocene of Hordwell. (B.M. No. 29,851.) $\frac{1}{1}$.

The Hordwell cranium has been so much crushed and broken that it has not been deemed desirable to give a figure of its upper surface; but the left side of the inferior surface and the cheek-dentition are figured in the accompanying woodcut (Fig. 5). The cheek-series comprises six approximated teeth, and one tooth (pm. 1) separated by a long diastema from the rest. The six approximated teeth are the last three premolars, and the three molars; the latter being in a partially worn condition, which indicates the fully adult condition of the specimen. The dentition is essentially brachydont, and it will suffice to say that the last six teeth agree precisely in form with those of typical species of *Anthracotherium*, and are in fact miniatures of those of some of the larger species of that genus.[1] The true molars differ *in toto* from those of typical species of *Hyopotamus*, like *H. bovinus;* although they approach those of some of the aberrant species like *H. porcinus*.[2] The second premolar (pm. 2) has a compressed simple crown; pm. 3 has a triangular crown; and pm. 4 has a distinct inner and outer column. These teeth are precisely like those of *Anthracotherium*, and differ slightly from those of the typical forms of *Hyopotamus*.[3] The isolated tooth (pm. 1) has a compressed conical crown, and is inserted by two distinct fangs, whence it may be regarded as the first premolar; from its relation to the nasals it was probably situated but a short distance behind the canine. In the larger species of *Anthracotherium*, the first premolar is either in contact with pm. 2,[4] or is separated by a comparatively small interval,[5] but the complete dental series of some of the smaller forms like *A. breviceps*[6] is not known. In the typical species of *Hyopotamus*[7] there is a long diastema between pm. 1 and pm. 2, but there is a still longer one between the former and the canine. In *Chœropotamus parisiensis*[8] there is a long diastema between pm. 1 and pm. 2; although this is proportionately smaller than in the present specimen. and the first premolar is relatively larger. The true molars of *Chœropotamus* are, however, readily distinguished by their more bunodont structure from the decidedly selenodont teeth of the present form. The crushed condition of the cranium admits of but little accurate observation. As in the *Anthracotheriidæ* in general, there is no tympanic bulla; the orbits are well defined, although incomplete posteriorly: there is a strong sagittal crest; and the nasals are relatively long. The occiput is like that of *Anthracotherium* and *Hyopotamus*. The anterior border of the posterior nares is situated a considerable distance behind m. 3; which is a character found in *Anthracotherium dalmatinum*,[9] and not in any of the typical species of *Hyopotamus*.[10]

The lower jaw shows both ràmi of the mandible, which have however been disassociated. The right ramus and the dentition are represented in the accompanying woodcut (Fig. 6). This ramus is complete, with the exception of the symphysis. In general form it resembles the mandible of *Hyopotamus*,[1] and of certain species of *Anthracotherium*, e.g. *A. hippoideum*, Rütimeyer.[2] There are six cheek-teeth in apposition, in advance of which there is a long diastema, and then the broken base of a tooth which is doubtless the canine. The three true molars correspond exactly with the Egerkingen teeth figured by Professor Rütimeyer, and are of a brachydont type, with an imperfect selenodont structure, and having a small tubercle at the entrance to the external valleys. The general structure of these teeth is very similar to that found in *Anthracotherium hippoideum*, and they are more brachydont than in typical species of *Hyopotamus*. The fourth premolar has fore-and-aft talons, with a large inner cusp; the latter being found of smaller size in some species of *Hyopotamus* and *Anthracotherium*. The third and second premolars have compressed conical crowns, with very minute talons; and are each inserted by two roots. There is no trace of the first premolar.

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[1] Compare *Anthracotherium illyricum*, Teller, Beitr. Pal. Oest. Ungar. vol. iv. pt. i. pl. xi.

[2] *Vide supra*, vol. i. p. 547 (1884).

[3] Vide Filhol, Ann. Sci. Géol., vol. xii. pls. xv-xix.

[4] *A. illyricum*, Teller, *op. cit.*

[5] *A. alsaticum*. Vide Filhol, Ann. Sci. Géol. vol. viii. pl. viii. (1877).

[6] *Vide* Böttger "Palæontographica," vol. xxiv. pt. 5, pp. 163-173.

[7] *Vide* Filhol, Ann. Sci. Géol. vol. xii. pls. xv-xix.

[8] Gervais, Zool. et Pal. Françaises, 2nd ed. pl. xxxii. fig. 1.

[9] Teller, *op. cit* pl. xiv. Prof. Teller refers this species to a separate genus—*Prominatherium*; but the present writer prefers to continue to refer it to *Anthracotherium*.

[10] Filhol, *loc. cit.*

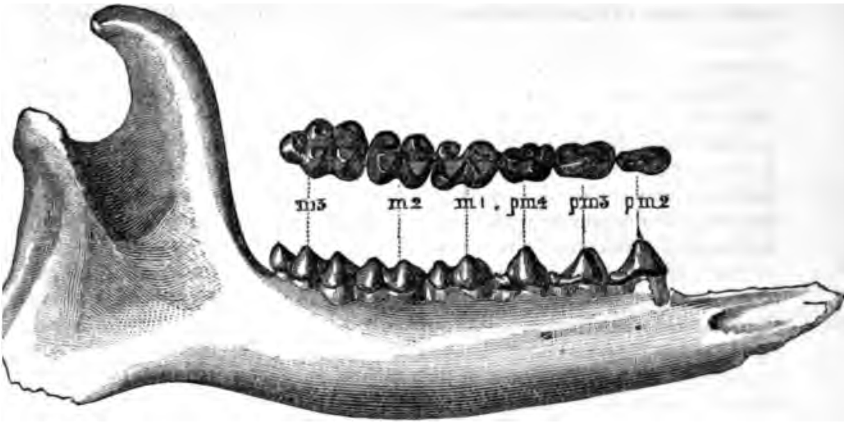

FIG. 6. *Anthracotherium Gresslyi* (Meyer). The right ramus of the mandible, and the lower dentition. (B.M. No. 29713.) ½.

In the described species of *Anthracotherium* (e.g. *A. hippoideum*) the first premolar is usually situated in the middle of a short diastema occurring between pm. 2 and the canine; and in *Hyopotamus*, pm. 1 is frequently situated very close to the canine, and falls out at an early period of life. The lower jaw under consideration evidently belongs to a specialized form, whose molar teeth agree with those of *Anthracotherium*, and the brachydont species of *Hyopotamus* (e.g. *H. porcinus*).

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[1] *Ibid.* pl. xxi.

[2] Denkschr. schw. nat. Ges. vol. xv. art. 8, pl. i. (1857).

The following table shows the chief dimensions of the specimen.

Cranium.—Height from lower border of foramen magnum to summit of occiput	0·034
Length from lower border of foramen magnum to pm. 1.	0·117
Length of space occupied by last six cheek-teeth	0·047
,, ,, 3 true molars	0·0265
,, diastema between pm. 1 and pm. 2	0·0205
,, m. 3	0·0095
Width ,, ,,	0·012
Mandible.—Extreme length	0·114
,, height at coronoid process	0·052
Depth at m. 3	0·017
,, pm. 2	0·015
Length of space occupied by six cheek-teeth	0·052
,, ,, ,, 3 true molars	0·030
,, m. 1	0·0085
,, m. 2	0·0087
,, m. 3	0·013
Width ,,	0·008

The foregoing comparisons indicate pretty conclusively that the Hordwell fossil as regards dental characters comes nearer to *Anthracotherium* than to *Hyopotamus*,[1] and although the differences from typical forms of the first-named genus would doubtless be regarded by some palæontologists as of generic value, the writer being strongly opposed to the multiplication of genera is inclined to refer it to that genus, and it may accordingly be known as *A. Gresslyi* (Meyer).

A. Gresslyi must be regarded as a highly specialized species of *Anthracotherium*, bearing the same relation to typical species of the genus, as the so-called genera *Plesiomeryx* and *Xiphodontherium* respectively do to the genera *Cænotherium* and *Xiphodon*, in which the writer is disposed to include them.

The addition of this species to the English Upper Eocene fauna is important, as it affords another instance of the intimate relations existing between the English and Continental Tertiary faunas. It also leads to the conclusion that the Egerkingen beds are closely related in time to the Headon series of Hordwell. The former beds are classed by Dr. Max Schlosser [2] immediately above the Paris Gypsum; while Professor Gaudry [3] places a part of them below the Calcaire Grossier.

The reference of the present species to *Anthracotherium* instead of to *Hyopotamus*, renders it necessary that *Tapinodon* should for the future be regarded as a synonym of the former, instead of the latter genus.

CHÆROMERYX SILISTRENSIS (Pentland).

From the Siwaliks of India.

In the Palæontologia Indica (ser. 10, vol. ii. pp. 149 166) the writer has shown that the name *Chæromeryx silistrensis* should be applied to the specimen from the Gáro Hills figured by Falconer and Cautley, under the name of *Anthracotherium silistrense*, in the "Fauna Antiqua Sivalensis" (pl. lxviii. figs. 22, 22*a*). At the time of writing that notice no trace of the specimen, which consists of a fragment of the right maxilla,[1] could be found; and judging from the figure, and a cast (which now appears very inexact), he was under the impression that it contained three teeth which were considered as the true molars. The original specimen has recently been found in the British Museum (No. 19040); and it really contains only two teeth, which are respectively the third and fourth milk-molars. A comparison of the fourth milk-molar of this specimen with an upper true molar from Sind which is figured in the "Palæontologia Indica" (*op. cit.* pl. xxiii. fig. 11), under the name of *Sivameryx sindiensis*, shows that the two are certainly generically, and very probably specifically the same; the slight differences between the two being not improbably merely due to difference of serial position. The figure in the F. A. S. does not exhibit very clearly some of the characteristic features of the Gáro Hills specimen; and from this, coupled with the reference of the teeth of this specimen to the permanent instead of the milk-series, the two specimens were referred to distinct genera.

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[1] The circumstance that *Anthracotherium* and *Hyopotamus* pass into one another (see GEOL. MAG 1884, Decade III. Vol. I. p. 548) does not affect the present species, as its upper molars are of the typical *Anthracotherium* type.

[2] Palæontographica, vol. xxxi. p. 96 (1884). The writer has recently found that *Adapis magna*, Filhol, of the Upper Eocene of the Continent, occurs at Hordwell.

[3] Les Enchainements, etc., Mam. Tert. p. 4.

It follows from the above that the genus *Sivameryx* must be abolished. *Chæromeryx* has been previously placed in the neighbourhood of *Merycopotamus*, but a recent comparison with specimens in the British Museum renders it probable that its affinities are rather with *Dichodon*.

The occurrence of *Chæromeryx* and *Anthracotherium silistrense* in Sind and the Gáro Hills renders it probable that at least a part of the Siwaliks of the latter district correspond to the lower division of that series.

IV.—NOTE ON THE *POSIDONOMYA BECHERI* BEDS OF BUDLE (NORTHUMBERLAND), WITH REMARKS ON THE DISTRIBUTION OF THE SPECIES.

By G. A. LEBOUR, M.A., F.G.S.,

Professor of Geology in the Durham College of Science, Newcastle-upon-Tyne.

BUDLE BAY, on the coast of Northumberland, between Holy Island and Bamburgh, is the estuary of the little river Waren. The rocks of the country belong to the Bernician Series or, in other words, to the alternating grits, limestones, shales, and coals which in northernmost England represent the Carboniferous Limestone Series. The northern shore of the Bay is a broad expanse of sand stretching as far as Fenham Flats and Holy Island, but the southern is rocky though not lofty. The Great Whin Sill (the well-known intrusive sheet of Basalt[2]) is present here, and the late Mr. G. Tate of Alnwick has more than once described it as it occurs here, associated with the beds which form the subject of this note. In 1872 he wrote: "At Budle the basalt is nearly connected with an indurated, jointed, red shale (containing *Posidonomya Becheri*, etc.), which overlies a limestone; for the basalt is in the hill a little above the schist, and on the sea-shore to the east; so that the jointed and indurated condition of the schist is probably due to the action of the Basalt."[1]

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[1] The figure in the F. A. S. is reversed.

[2] Or *Diabase*, as Mr. Teall tells me I had better now call it.

As early as 1853, however, Mr. Tate had called attention to the occurrence of the fossil in question. In his Presidential Address to the Berwickshire Club on the 7th of September of that year, he alluded to the "Budle schists . . . filled with rare and beautiful remains of fossil plants and animals belonging to the Carboniferous era."[2] In a similar address delivered in 1864, by Mr. Wm. Stevenson of Dunse, the then President of the Club, is the following passage, which I believe was at least inspired by Mr. Tate: "Proceeding onwards to Budle Bay, the well-known Posidonia shales were examined with much interest. These shales of a reddish brown colour, abounding in the shells of the fragile Posidonia, associated with the remains of a few land plants, have evidently been deposited in the still brackish waters of an ancient lagoon or estuary, little disturbed by tidal action."[3]

The above quotations, which, considering the scarcity of the back volumes of the Berwickshire Transactions, I make no excuse for giving in full, comprise about all that can be said in the way of description as to the Budle Shales. They are red, rather hard, and much jointed; they contain numerous plant remains in the form of drifted narrow ribbon-shaped leaves, showing little or no structure, and not easy to determine; but the most interesting fossil is undoubtedly the *Posidonomya*, which gives its name to the beds in which it occurs. The specimens are abundant; but, owing to the way in which the shale breaks up, it is somewhat difficult to obtain good specimens. With this shell are species of *Lingula*, *Spirifer*, *Chonetes*, *Orthis* and *Euomphalus; L. mytiloides*, *Sp. bisulcatus*, *O. Michelini*, *Eu. pentangulatus* being the commonest. Other fossils occur; among them I have found a *Bellerophon*, a *Phillipsia* (tail only) and some *Polyzoa*, whilst one *Gonatites* (*G. atratus*, Goldf.) is recorded by Mr. Tate; but with the exception of a *Fenestella*, these are all rare. Corals and Crinoids are conspicuous by their absence, and after many searches, I have never seen but one specimen of the otherwise ubiquitous genus *Productus*, and that was *Pr. fimbriatus*, by no means a common Northumbrian form.

Mr. Tate placed the horizon of these shales rather low down in his "Calcareous Group" of the Carboniferous Limestone Series of Northumberland, between the two beds of limestone known locally as the *Stone Close* or *Five-Yard* and the *Hobberlaw* or *Four-Yard* limestone. This is a point of much difficulty, owing to the faulted condition of the series in the Bamburgh and Budle district, and more especially to the presence of that disturbing element the Great Whin Sill, which there runs in and out among the sedimentary deposits in a very bewildering manner. In 1878, I hazarded the following statement on the subject:—"The interesting fossil *Posidonomya Becheri* occurs at Budle and in the neighbourhood of Alnwick, and appears to be confined to the Upper Bernician Series. Its exact horizon is doubtful."[1] I am not in a position to add anything to this statement; but the *exact horizon* is *certainly* within the limits of the Bernician, *probably* in its upper portion, and will be known as soon as the results of my friend Mr. W. Gunn's work on the Government Geological Survey of the district are published. At any rate the beds under discussion are some thousands of feet above the Tuedian.

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[1] See G. Tate on "The Basaltic Rocks of Northumberland," Berwickshire Naturalists' Transactions, 1872, p. 200.

[2] Berwickshire Transactions, vol. iii. 1857.

[3] Berwickshire Transactions, vol. v. p. 104. See also Baker and Tate's "New Flora of Northumberland and Durham," 1868, p. 10; and Tate's "History of Alnwick," vol. ii. 1869, pp. 454, 455, and 457.

The other localities in the North for *Posidonomya Becheri* are the Cawledge Burn near Alnwick, where it was found by Mr. Tate; a small quarry near Denwick (also in the neighbourhood of Alnwick) where Mr. Topley, I believe, first saw it, and where I have myself gathered it; and lastly at Lowick, where the late Rev. Mr. Jenkinson collected it. All these localities are in the Upper Bernician.

The range of *Posidonomya Becheri* is a subject of great interest. Wherever the Carboniferous Limestone series puts on a shaly facies, there it seems to be present. Many years ago I had the pleasure of seeing specimens of that and another species of the same genus from the shales of Lower Carboniferous age of Western Scotland in the collections of Messrs. James Thomson and Armstrong in Glasgow. Then come the Northumbrian Bernician shales, and next the Devonshire Culm shales with *Posidonomya* as described by Dr. Woodward and Mr. J. E. Lee, to the latter of whom I am indebted for beautiful specimens in a shale wonderfully similar in aspect to that of Budle. On the Continent wherever the *Bergkalk* gives place to the *Kulm*—in other words, wherever the Lower Carboniferous sea was shallow and had a muddy instead of a limy bottom, there *Posidonomya Becheri* invariably appears, as Dr. Ferd. Roemer and others have so well shown. I have lying before me a little collection of *Posidonomyæ* from Silesia, Nassau, and Portugal due chiefly to Dr. Roemer's kindness and including a beautiful specimen quite recently brought from the slaty beds in Southern Spain in which the great Rio Tinto mines are situated, and presented to this College by Mr. David Tyzack. All these specimens, altogether from some fifty places representing a vast extent of country, are absolutely indistinguishable except as to the degree of alteration which the shales containing them have undergone; and the occasional fossils of other kinds which are visible on the slabs are likewise very similar, the presence of long ribbon-like leaves of plants being remarkably general.

It is perhaps not possible to dogmatize yet as to the limits of the vertical range of *Posidonomya Becheri.* I have paid a good deal of attention to the subject, and cannot find any limits (taking all Europe into consideration) to its range within the Lower Carboniferous rocks. In England, however, it has never yet been recorded from beds of Tuedian age, nor, taking into account the nature of the Tuedian deposits, is it very likely that it may ever be found in them.

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[1] Lebour's "Outlines of the Geology of Northumberland," (1878), p. 68.

V.—ON THE OCCURRENCE OF A MINERAL ALLIED TO ENSTATITE IN THE ANCIENT LAVAS OF EYCOTT HILL, CUMBERLAND.

By Professor T. G. BONNEY, D.Sc. LL.D., F.R.S., Pres. G.S.

THIS interesting series of ancient volcanic rocks is described by the late Mr. Clifton Ward in a paper on the Microscopic Structure of Ancient and Modern Volcanic Rocks, read before the Geological Society,[1] in a Memoir of the Geological Survey on the Lake District, and, in greater detail, in a communication to the Royal Microscopical Society.[2] All these are illustrated by figures (in no case very good) and some chemical analyses are given in the last-named paper. I went to the hill in the autumn of 1874 and collected a few specimens, but my visit was cut short by heavy rain. A few weeks since Mr. J. Postlethwaite of Keswick, to whose kindness I have been more than once indebted for additions to my collection, forwarded to me three specimens from Eycott Hill, thinking that I might not have any rocks therefrom, and called my attention to the peculiar reddish tint of the felspar in one of them, which, as he remarked, "resembled the colour of a garnet." These were varieties of the well-known porphyritic lava of Eycott Hill, which is described by Mr. Ward as the second lava bed in ascending order, and as being above 100 feet thick. This specimen was obtained from a boulder on the hill. On examining it and comparing it with my own (at which I had not looked for some years), I was struck with the appearance of the ground-mass, which seemed to me unusually compact and more like that of an augite-andesite, than of a dolerite or diabase, as the rock is named by Mr. Ward. I had a slide prepared by Mr. Cuttell from Mr. Postlethwaite's specimen, in which I first discovered the mineral which is described in this note, and have since had some more cut from my own specimens from Eycott and others subsequently sent by him, and (for comparison) from the lavas of Falcon Crag near Derwentwater.

The Eycott rock is described by Mr. Ward as having "a compact greenish-blue base, containing dark green spots of a soft mineral and large porphyritically imbedded felspar crystals, many of them an inch long. . . . . The top of this lava is beautifully vesicular in parts, the vesicles being drawn out along the line of flow and filled with chlorite, chalcedony, and calcite." The "dark green spots" I may add generally do not exceed ·1 inch in diameter, and I should be disposed to call the base a dark "slate" colour, commonly with a greenish tinge (slightly purplish in Mr. Postlethwaite's specimen), rather than a "greenish-blue"; the felspar crystals are in the normal specimens a greyish olive-green.

[1] Q.J.G.S. vol. xxxi. p. 406.

[2] Monthly Microsc. Journal, 1877, p. 239.

The felspar crystals, with the above described greenish spots, and some grains of iron oxide, belong to an earlier stage of consolidation, or, possibly one should say, of crystal-building. As Mr. Ward points out, they cannot have been separated out of the mass when it flowed as a lava. I have little to add to his careful description, except that I believe these felspars to be labradorite, and doubt the possibility of any of them being orthoclase. In Mr. Postlethwaite's specimen a few scales of iron-glance are scattered about in the felspar crystals, but not in such numbers as one would expect from their ruddy tint before being sliced. The soft dark spots are regarded by Mr. Ward as pseudomorphs in many cases after augite, and some, he says, "seem to be after olivine, presenting the form and much-fissured appearance of that mineral. I have detected grains of olivine in an unaltered condition in some of these lavas, and therefore think there can be no doubt that both it and augite were common constituents at one time, though both have been so much replaced by pseudomorphous minerals through subsequent alteration." It is of course quite possible that my lamented friend may have detected olivine in some of the upper lavas, which I have not examined; but I think he has erred in his reference of these dark green spots either to augite or olivine, as will be seen from the following description. But I do not in the least doubt the presence of moderate-sized crystals of augite, which however seems to be always in fair if not good preservation, in addition to that which occurs in the ground-mass.

The mineral of which we speak is obviously a magnesian silicate, which has generally been converted, since the consolidation of the rock, into a kind of serpentine. In form it is usually a rather irregular oblong, about twice as long as it is broad, with a slightly worn or corroded aspect at its edges; and it is very commonly bordered by clustered opacite, as is frequent with hornblende and mica in an andesite. Hence the external crystalline form is generally not well defined. There is one well-marked cleavage parallel with the longer sides of the grain, with, I think, an indication of a second, which makes a large, if not a right angle with the other, and possibly a third; but these are often only suggested by the presence of rather irregular cracks, so that it is not possible to be certain about them. Indications of a fibrous structure, parallel with the dominant cleavage, may also be observed. With transmitted light the usual colour is a pale sap-green, but sometimes the inner, sometimes the outer part of the crystal is slightly browner. The mineral has evidently undergone alteration, but in one crystal a portion remains apparently unchanged, and this is of a pale greenish straw colour. All exhibit a fairly well-marked dichroism. When the principal cleavage lines are parallel with the vibration plane of the lower Nicol, the tint is a pale sap-green; when perpendicular, it is a pale yellowish-green. With crossed Nicols, extinction takes place when the dominant cleavage lines are parallel with either vibration plane; when they are at an angle of 45° with these, the colour in the unaltered part is a straw-yellow, the tints in the altered parts being paler, and such as are usual with serpentinous minerals. I notice that the browner and greener parts mentioned above do not extinguish simultaneously. The mineral contains a few scales of iron-glance and some light brown granular endomorphs, which occur also in the ground-mass[1] but is generally rather free from inclusions. Obviously we have here a magnesian silicate containing some iron, which is more or less converted into a kind of serpentine. Clearly it is not olivine, neither is it normal bastite. It does not correspond with hypersthene, especially with the small crystals of that mineral which have of late been noticed in so many andesites. Its general aspect agrees with that of some of the more or less altered enstatites and bronzites with which I am familiar from my studies of serpentines, and it reminds me also of the representations given of altered enstatite and of so-called bastite by Fouqué and Lévy (*Mineralgie Microscop. Roches Eruptives Françaises*, plates xxvii., liii., and liv.)

The ground-mass, in which the above-described minerals are embedded, consists of lath-like crystallites of plagioclase felspar, of grains and imperfectly developed little crystals of augite, and of crystals and granules of iron-oxide, which probably is mostly hematite. There are occasional scales of iron-glance. These are thickly set in a brown glass-like base. This when examined with objectives of fairly high power—say from $\frac{1}{4}$ to $\frac{1}{8}$ of an inch—becomes paler and greyer in colour, and is found to be crowded with dark granules and blackish belonites, which are sometimes slightly curved. These occasionally seem to interlace so as to form a kind of network. Similar microliths, but with a brush-like grouping, are figured by Rosenbusch in a hydrotachylite[2] (*Microscop. Physiograph.* vol. i. plate iii.). These belonites occur in the slide prepared from Mr. Postlethwaite's specimen; in that from a specimen collected by myself they are, if not absent, exceedingly rare. The general character, however, of the ground-mass of the latter corresponds with that of the former. So far as I can ascertain, the base is still a true glass, and has not undergone devitrification.

After I had informed Mr. Postlethwaite of the result of my examination of his first specimen, he again visited Eycott Hill, forwarding to me fresh fragments of the redder variety broken from the rock *in situ*, and then a block, also obtained *in situ*, which exhibited a passage from that variety to the normal rock. I have had a slide cut from the extreme parts of this, for the transition from the one tint to the other is too gradual to offer anything like a junction. The two slides when examined under the microscope are almost identical, the only difference being that in the redder variety small scales of burnt-sienna coloured iron-glance are more numerous, and in its ground-mass the dark belonites are more frequent than in the normal rock. Also I think that the base of the former, when viewed with a low power, is a shade browner than that of the latter. The description given above serves as a whole for these slides also. Each,

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[1] They are not isotropic. Probably they are alteration products, possibly ferruginous. They often occur in somewhat altered igneous rocks.

[2] Similar needles are figured by Prof. Judd and Mr. Cole in their admirable paper on the Basalt Glass of the Western Isles of Scotland, Q.J.G.S. vol. xxxix. p. 444.

I may remark, contains some sections of the supposed altered enstatite. Many of these exhibit one well-marked and fairly frequent cleavage, with two others much less perfectly developed; one being very nearly at right angles to, and the other making an angle of about 26° or 27° with the first. Thus these two include between them an angle not far from 60°, but where the principal cleavage is not visible in the slice, then the irregular cracks appear to meet much more nearly at right angles. The slide from the normal rock contains five or six crystalline grains, roughly clustered together. Not one has quite escaped change, but in several we see a rather broad fibrous-looking border of a pale green colour, which gives uniform and clear tints with the crossed Nicols, while the interior is confusedly fibrous in structure and in large part dark, besides being a rather stronger green colour with ordinary light. Here and there we have a grain which is not much more altered than the one already described.

Above the porphyritic lava just described comes a series of lavas noticed in Mr. Ward's paper. I possess a specimen from the lowest of these (I believe that numbered 6 in his section). It is porphyritic, but the felspar crystals are much smaller than in the other rock, not generally exceeding a quarter of an inch in the longer diameter. These under the microscope appear to be more broken and corroded than they are in the rock below. The altered "enstatite" is also present in about the same quantity, but it too has a slightly more corroded aspect and is more thickly black-bordered than in the other. The ground-mass is of the same general character, but the crystallites are smaller, and the base, which with a low power is darker, seems to be of a green hue, and more crowded with microliths. The dark border of the enstatite also seems to be resolved into minute granules of a partly translucent mineral, probably augite, mingled with ferrite.

In the lowest of the lavas at Falcon Crag I find a little of what I believe to be the altered enstatite, though it is much more irregular in form, more interrupted by inclusions, and altogether less well characterized than at Eycott Hill, so that I should hardly have ventured on identifying it from these slides. In this lava there is also a fair quantity of well-preserved and characteristic augite (diameter commonly about ·03 to ·05 inch). I do not detect the enstatite in either of the slides from the next two lava-flows.

I think then there can be no doubt that the Eycott Hill lavas contain a variety of enstatite. It might be possible, but it would be difficult, to isolate a sufficient quantity for chemical analysis, but to my mind the evidence as to its nature is already sufficiently clear, and the only point on which we require enlightenment is whether enstatite or bronzite would be the better name. The settlement of this point I willingly leave to any one who thinks it worth the time and labour, for I feel confident that the mineral is a bisilicate of magnesia with some iron.

From the aspect of the ground-mass of the Eycott Hill rock, and the presence of the bisilicate, enstatite, instead of the unisilicate, olivine, I should not have been surprised if it had proved to be chemically more nearly related to the Falcon Crag lavas than to those which succeed it at Eycott Hill. Analyses of the latter, quoted by Mr. Ward in the paper mentioned above, show the silica percentages of three of them to be respectively 53·3, 52·6 and 51·1. The Falcon Crag rocks are shown by Mr. Ward (though he coined for them the unhappy term *felsidolerite*) to be in reality andesites, which microscopically and chemically[1] present only such differences from the modern representatives of that group as we should naturally expect in rocks of such great antiquity. By the kindness of Prof. A. W. Williamson, the silica percentage of the red variety of the Eycott Hill rock has been determined for me by Mr. T. Cooksey in the laboratory of University College. He finds it to be 53·06 (one determination giving 53·40 another 52·73)[2] with a specific gravity of 2·754. The rock must therefore remain among the basalts (the glassy condition of its base renders the name dolerite inappropriate). It belongs, however, to the side of the basalt group which is the richer in silica, and is nearly represented among modern rocks by some of the basalts of the Inner Hebrides in Prof. Judd's collection. It also resembles in certain respects some of the magma basalts described by Boricky (*Petrographische Studien an den Basaltgesteinen Böhmens*). The amount of alteration may justify us in naming it now an enstatite-diabase, but I feel no doubt that it was originally a true basalt rich in glass, containing a variety of enstatite.

REVIEWS.

Dr. Fritsch's Permian Amphibians of Bohemia.

DR. ANTON FRITSCH has now made such progress with his Monograph on the Fauna of the Bohemian Permian rocks that we are able to recognize it as one of the most important and one of the ablest of modern contributions to Palæontology. For excellence of description it has not been surpassed; while from the minute dimensions of most of the Amphibian remains, care has been required in deciphering osteological characters, which has resulted in a perfection of osteological labour. Specimens offering fewer difficulties might not perhaps have been studied with the same completeness. Professor Fritsch has shown that he is a learned comparative anatomist, whose wealth of knowledge has enabled him to enrich his pages with the fruits of many and varied studies, and to successfully interpret remains which are often obscure.

The third part of the work contains descriptions of *Urocordylus scalaris*, *Keraterpeton crassum*, *Limnerpeton modestum*, *L. laticeps*, *L. macrolepis*, *L. elegans*, *L. obtusatum*, *L. dubium*, *L. difficile*, and a note on *L. caducum*. Like the foregoing part it consists of 32 quarto pages of text, well illustrated by many excellent figures printed with the text; and by 12 coloured plates.

The memoir begins with some account of the family Nectridea, which are long-tailed lizard-like animals, usually with elongated epiotic horns, and tail vertebræ devoid of ribs, but with the upper and lower spinous processes expanded in fan-like form. The genus ***Urocordylus***, which was established by Huxley and Wright, has the head triangular, blunt in front, and truncated behind, with the cranial bones covered with round pits, which suggest those on the skulls of crocodiles. The strong tail includes about 80 vertebræ. The strong ribs are double-headed, and about three times as long as the vertebræ.

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[1] Two analyses of lavas from the Keswick district given in the Survey Memoir give silica percentages of 60·718 and 59·511 respectively.

[2] He also writes, "The rock contains a small amount of calcium, less magnesium, but mainly iron, aluminium and silica."

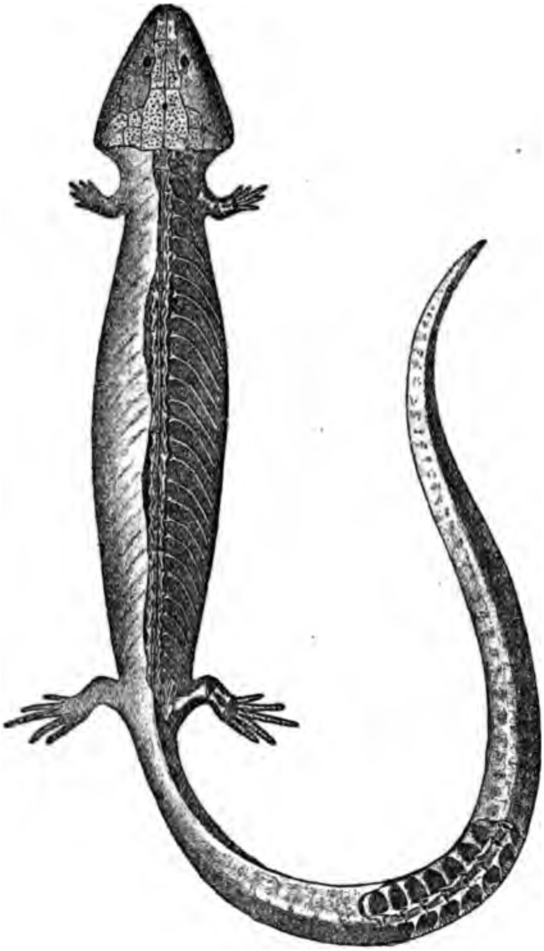

FIG. I.—Restoration of *Urocordylus scalaris* (Fritsch).

The thin shield-shaped thoracic plate is expanded in front. The lateral thoracic plates are broad and spoon-shaped. The abdominal scales are smooth and elliptical. The feet are five-toed; the hinder limbs are longest. The *Urocordylus scalaris* of Fritsch is distinguished from the *U. Wandesfordii* of Huxley by having broader spinous processes to the caudal vertebræ, but the distinction is not of a striking kind; and the remains are imperfectly preserved. The restoration is founded partly upon the Bohemian fragments, partly upon Irish specimens. The head is one-fourth of the length of the body, and the body is about one-half the length of the tail. From the proportions of the body and limbs, the animal is presumed to have been essentially aquatic, and from the well-developed abdominal armour is inferred to have crawled along the bottom. There are no indications of scutes on the upper side of the body or on the tail. The abdominal armour consists of more than 100 rows of somewhate elongated scutes, which vary in size and form. They commence behind the thoracic plate, and are arranged in oblique series of three or four on each side of the median line, overlapping on the inner side.

The form of the skull is more elongated than in *Keraterpeton.* The eyes were small, in the anterior half of the head, and separated from each other by three times the diameter of the orbits. There are eleven teeth on the palatine bone. The number of presacral vertebræ is unknown, but is estimated at 27 as compared with 20 in *Urocordylus Wandesfordii.* The vertebræ are strong and well ossified, and terminate in fan-shaped neural spines, which are serrated like a cock's comb. The specimens figured are from the first third of the tail, and show the dorsal and ventral processes. These caudal vertebræ are compressed from side to side. Their number is unknown, but supposed to be about 80, as in the Irish

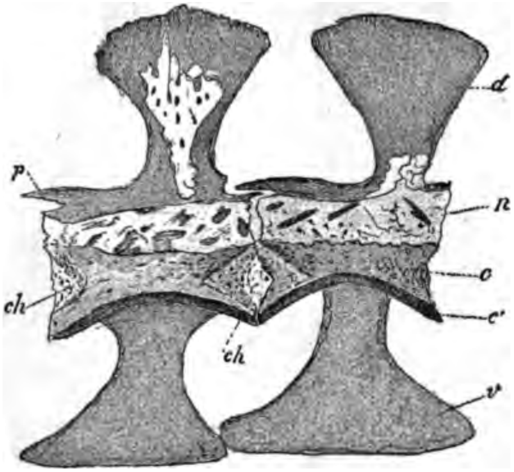

Fig. II.—Tail Vertebræ enlarged six times.

d, dorsal process; *v*, ventral process; *p*, pre-zygapophysis; *ch*, notochord; *c*, body of vertebra; *n*, neural canal.

species. The ribs are hollow. In the anterior extremity only the small humerus has been recognized. The hind limbs were twice as strong as the fore limbs. There are no traces of gill arches.

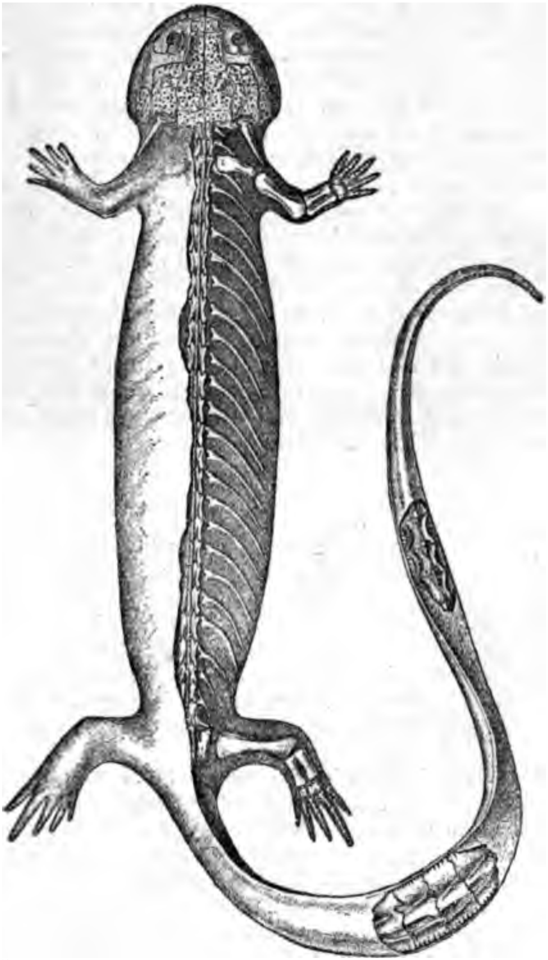

Fig. III.—Restoration of *Keraterpeton crassum* (Fritsch); 1½ times natural size.

A short account is given of the genus *Keraterpeton*, based upon Huxley's memoir, and then follows a description of the species *K. crassum* (Fr.). This is the only Bohemian species. It has the orbit of the eye small and placed well forward, and has a head smaller in proportion to the body than in the British species. It is known from three complete specimens and fragments of thirty others. The animal was much smaller than *Urocordylus*, but of a stronger build. The head has a wide frog-like form, with the characteristic epiotic spines (see Fig. 3). The body is five times as long as the head, and the tail more than twice as long as the body. The limbs have a development which suggests locomotion by walking, and the small height of the processes of the caudal vertebra would indicate a comparatively bad swimmer. The skeleton is completely ossified, even the carpus and tarsus being here preserved. No indication of the skin is preserved, but there is a shield of strong armour which covers two-thirds of the width of the abdominal surface, and extends between the thoracic plates and the pelvis. This shield consists of more than forty rows of long rhomboid plates, directed obliquely backward from the median line, and has about eight keeled plates in each row. Each plate has four circular pits on its inner edge, which resemble the pits on the cranial bones. In the skull deep depressions in front of the nasal bones indicate the nares. The circular pits on the skull are absent from the inner part of the frontal bone. The premaxillary teeth, five on each side, are pointed, and constricted towards the base so as to have a spoon-shaped contour. There are about eleven or twelve teeth in the maxillary bone in one row. As the number of teeth indicates a small gape to the mouth, Professor Fritsch infers that *Keraterpeton* fed upon the small Crustacea and Myriapods which occur in the Bohemian coal. The epiotic horn, which is attached to the square epiotic bone, is wedge-shaped, and four times as long as the base is wide. Its length is half the length of the skull. Its under surface is furrowed. The orbit contains a circle of about twelve or fourteen sclerotic plates. No new light is thrown on the gills or hyoid arch; and it is probable, from the absence of gills, that they were lost early in life.

The number of the pre-sacral vertebræ is uncertain, but is believed to be about 23; they are similar in size and shape, and all carry ribs. The centrum is constricted in the middle. There are 40 caudal vertebræ. As in *Urocordylus*, there are no interspaces between the dorsal and ventral processes of these vertebræ. There are no caudal ribs.

The middle thoracic plate is triangular, with a T-shaped elevated mass upon it like the interclavicle of *Ichthyosaurus* in form, with circular pits in the bone on each side of the median bar of the T. The lateral thoracic plate is formed of an oval shield with a short round curved stalk. It is pitted on the outer edge.

The fore-limb is shorter than in the Branchiosauridæ. The humerus has the usual constriction in the middle, is widest at the distal end, and has an elevated ridge on the upper end. The bones of the fore-arm are half the length of the humerus. The number of carpal bones is unknown. The metacarpal bones and phalanges are short, so that the hand is shorter than the fore-arm. The terminal phalanges are blunt and conical. The hinder extremity is stronger, with digits which are relatively quite as short. The number of bones in the several digits is 1, 2, 3, 2, 1.

The next family is named Limnerpetidæ. It is a group of Amphibians with broad frog-like head and long salamander-like body; and is armoured with sculptured scutes. The first species, *Limnerpeton*

modestum (Fritsch), is known from a lower jaw in which the bone is sculptured and the short conical teeth are of uniform size, which is 2½ times as long as wide. The second species, *Limnerpeton laticeps* (Fritsch), is 160 mm. long, but badly preserved. It had the form of an Axolotl, and has been restored from a specimen found at Tremosna. There is no indication of the skin. Scale armour was developed on the ventral surface between the pectoral and pelvic regions, where there are 54 rows of short wide scutes, each row consisting of about 8 scutes. The scales were 4½ times as wide as long; they are marked with concentric lines, between which there are rows of minute punctures.

The skull is nearly as broad as long, rounded in front. The orbits are large and nearly circular. There were more than 40 small even-sized teeth in the upper jaw, each half a millimetre in diameter, with with a large pulp-cavity. The epiotic bone is small and extends backwards into a short point. The squamosal bone is not divided as in *Dawsonia* and *Melanerpeton*. There are 24 presacral vertebræ bearing ribs. In the tail 22 caudal vertebræ can be counted, but there were probably 30, and many of these vertebræ carry short ribs. The vertebræ are very deeply biconcave. Of the pectoral girdle, the only element known is the middle thoracic plate. The lateral thoracic plate or coracoid has a stalk-like process. The anterior extremities are strong, with the humerus nearly twice as long as the fore-arm, and the phalanges are short and slender; and the hind limb is similarly characterized.

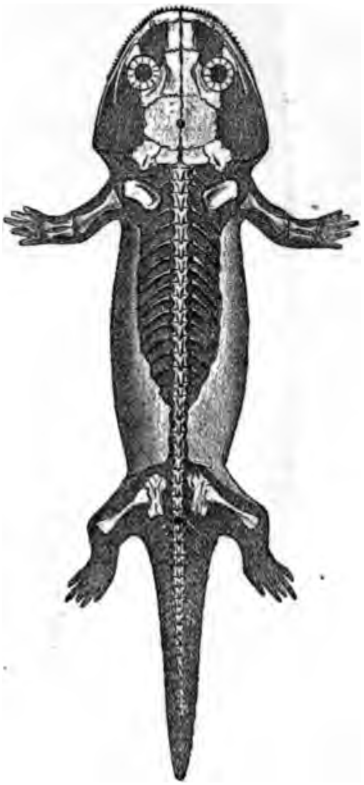

Fig. IV.—Restoration of *Limnerpeton laticeps* (Fritsch); natural size.

The third species *Limnerpeton macrolepis* (Fr.), is characterized by quadrate scutes, one and a half times as wide as high, marked with longitudinal striæ, and having the hinder edge thickened. There are about twelve teeth in the premaxillary bone, distinguished by having their points furrowed. There are about forty blunt-pointed teeth in the maxillary bone. There are more than forty teeth in the lower jaw. The form of the vomer is complicated. The middle thoracic plate is marked with radial striping. The vertebræ were slightly ossified and constructed on the amphicœlous

Fig. V.

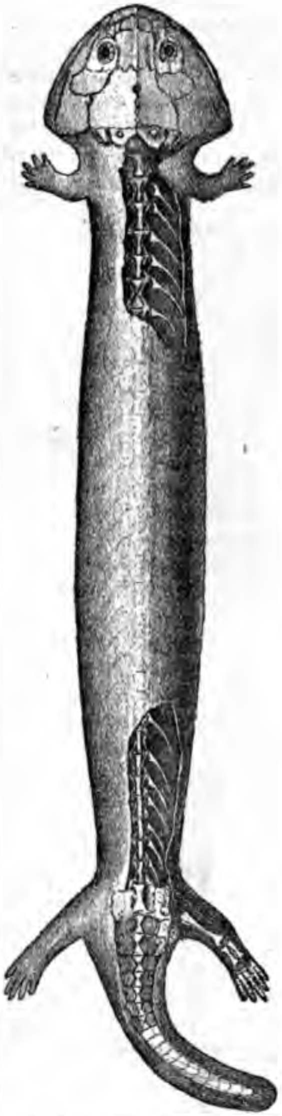

Fig. VI.

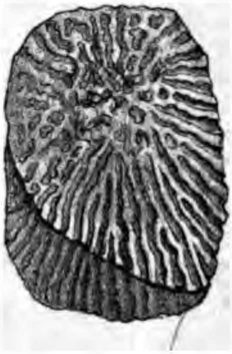

Fig. VII.

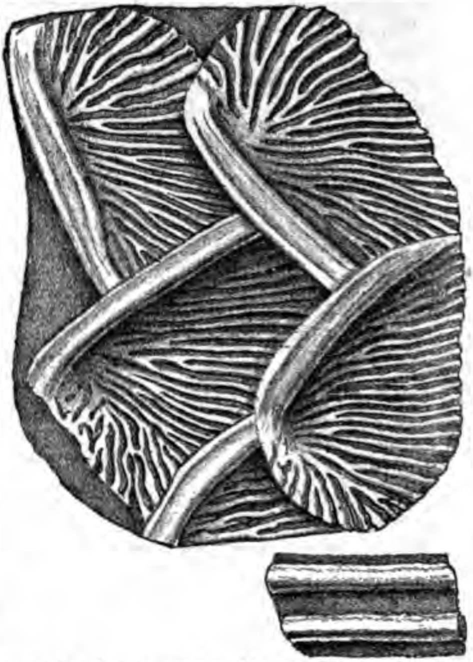

Fig. V.—Restoration of *Limnerpeton obtusatum* (Fritsch); natural size.
Fig. VI.—Caudal scute from the tail enlarged 45 times.
Fig. VII.—Scutes from the middle of the abdomen, *Limnerpeton obtusatum* (Fritsch); enlarged 45 times.

plan. The ribs are short with both ends expanded. The fourth species is *Limnerpeton elegans* (Fritsch). It has small oval scutes marked with cancellate marking which is partly concentric, partly diagonal. The remains are scattered. The skull-bones are comparatively smooth. They indicate a longer and smaller skull than that of the last species. The maxillary bone contains 23 teeth and may have included 35 teeth. The teeth are less regular in size than in other species of this genus. The shield of the parasphenoid bone is thickly toothed. The fifth species is *Limnerpeton obtusatum* (Fritsch). The scutes on the abdomen are of moderate size ornamented with ribs which branch at intervals, and have a thickened hinder edge. The scutes of the upper side of the body want the thickened edge.

The form of the body is greatly elongated, and the head is remarkably short and wide. The body is six times as long as the head, and the tail is twice as long as the head. The anterior extremity is much shorter than the hinder extremity. The abdominal armour consists of about 100 rows of scutes; each row contains six scutes on each side of the median line. Each scute is twice as broad as long. The skull is half as broad again as long. The orbits are in the anterior third of the skull, and are nearly double their diameter from each other. The teeth are small and smooth with pulp-cavities. The nasal bone is pitted. The epiotic bone is quadrate and ends in a process which is directed backward. The sclerotic circle includes 12 bones. The hyoid in so far as it is preserved resembles that of *Keraterpeton*. There are about 37 presacral vertebræ, and about 16 in the tail, though 10 appear to be wanting. The notochord was continuous. The caudal vertebræ are very short and decrease rapidly in height. The dorsal ribs are 2½ times as long as the vertebræ, and have the capitulum and tuberculum most developed towards the neck. In the hinder extremity the phalanges are remarkably short.

Some other remains are described under the names *Limnerpeton dubium*, known only from a lower jaw; *L. difficile*, known from a portion of a skull which is doubtfully referred to the genus; and *L. caducum*, founded upon a jaw and a rib.

Although many species have been described, it is impossible not to recognize that they are for the most part well characterized. And the publication of electrotypes of these perishable specimens will facilitate a comparison between some of the Bohemian species and their British allies, and thus demonstrate the nature of the affinity between them. H. G. SEELEY.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—December 3, 1884 (*Continued*).—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair. The following communication was read:—

3. "On the Lower Eocene Plant-beds of the Basaltic Formation of Ulster." By J. Starkie Gardner, Esq., F.G.S.

The paper commenced with a brief outline of the physical features of the basaltic area in Ireland. The beds whence plants have been obtained form a quadrilateral, the angles of which are Ballintoy, Glenarm, Ballypalady, and Lough Neagh. The Ballintoy beds are very incompletely explored, and have so far yielded few species. The Glenarm beds are situated in a disused mine, filled with water, which was drained by the author. The plants are well preserved in a matrix of white sandy clay. The Ballypalady plants are less perfectly impressed in a matrix of ochreous earth. Many of the plants are common to both; but Ballypalady possesses a whole group of conifers, including a cypress, yew, many pines and firs, not met with elsewhere; while Glenarm is richer in leafy trees. Among the plants in common are two which still exist, *Cryptomeria*, and a peculiar *Pteris* with reticulated venation. Among extinct plants the presence of *Macclintockia* especially points to their age being the same as the Heersian flora of Gelinden in Belgium. a stage very low in the Eocene. The Lough Neagh beds are estimated to be as much as 500 feet thick, and their flora shows them to be interbasaltic, and therefore Eocene instead of Pliocene as hitherto sometimes supposed. The great extent these beds formerly held is shown by the area over which silicified wood derived from them lies scattered. The basalts, here as elsewhere, have been enormously denuded; and the author believes that the horizon of the Mull leaf-bed is not anywhere present in Ireland. The Mull bed is regarded in this paper as probably of the same age as the Woolwich and Reading series of the London Basin; it was deposited on the flat banks of a river, liable to inundation; while the Irish beds, are fluviatile, not lacustrine, with the probable exception of those of Lough Neagh, which may be lacustrine.

II.—December 14, 1884.—W. Carruthers, Esq., F.R.S., Vice-President, in the chair.—The following communications were read:

1. "On the South-western Extension of the Clifton Fault." By Prof. C. Lloyd Morgan, F.G.S., Assoc. R.S.M.

This fault cuts across the strata out of which the Avon gorge has been excavated, a little north of the Suspension Bridge. According to the author's estimate, the throw of the fault is, on the Gloucestershire bank, somewhat less than 1200 feet, and somewhat more than 1100 feet on the Somersetshire bank. The difference of nearly 100 feet the author considered to be, in part at least, due to the dying-out of the fault to the west. Taking as a datum-point the intersection of the line of fault and the line of high-water mark, the rocks relatively shifted downwards are, on the Gloucestershire bank, Mountain Limestone 730 feet, Upper Limestone Shales 470 feet. According to this estimate, there would be 130 feet of Upper Limestone Shales above high-water mark, above which beds of Millstone Grit would be brought down. This accords with observed facts. On the Somersetshire bank the beds brought down below high-water mark are Mountain Limestone 770 feet, Upper Limestone Shales 330 feet. According to this estimate, there would be 270 feet of Upper Limestone Shales above high-water mark, which would thus leave little or no room for Millstone Grit to be brought down to the surface. Nor has the author succeeded in finding any sign of this rock on the Somersetshire side.

Owing to the fact that *softer* Upper Limestone Shales are brought down by the fault, its westward extension may be traced by a *line of depression* resulting from the greater erosion of these softer beds. In the map which the author exhibited, a triangular wedge of Upper Limestone Shales, brought down by the fault, had its apex near Hill Farm (see Survey Map), and its base abutting on the Triassic beds south of Durdham Down. If the fault do not tend to die out westwards, the apex of this triangle must be placed further S.W., for which there is no evidence, while there is some against it. The southern side of the triangle marks the line of fault. Further west the author believed that evidence exists of the faulting-down of a wedge of Mountain Limestone into the Lower Limestone Shales.

2. "On the Recent Discovery of Pteraspidian Fish in the Upper Silurian Rocks of North America." By Prof. E. W. Claypole, B.A., B.Sc. London. F.G.S.

The fossils now described from Pennsylvania are the first authentic remains of fishes found in the Silurian rocks of America, and some of them are the oldest undoubted vertebrates yet discovered. Previously fish had not been detected in America below the Devonian Corniferous Limestone of Ohio, and the Lower Devonian of Canada.

The most important fish-remains hitherto known from beds of Silurian age are from the bone-bed of the Upper Ludlow rocks, one specimen, the oldest in Europe with the exception of Pander's doubtful Conodonts, having been recorded from the Lower Ludlow. The fossils now described are closely allied to the two Ludlow types and consist of the spines known as *Onchus*, and the shields referred to *Scaphaspis* and belonging to the peculiar family Pteraspidæ.

The author entered into a detailed comparison of the English Silurian Pteraspids as described by Professors Huxley and Ray Lankester, and those now discovered in America. He described the three layers of which the shields of the Pennsylvanian Pteraspids are composed, and proposed for their reception a new genus, *Palæaspis*. He considers the Pteraspidæ, in which no bony structure has been detected, a distinct family from the Cephalaspidæ, which exhibit that structure.

He then proceeded to correlate the American beds yielding *Palæaspis* with the Ludlow beds of England. The American fish were chiefly found in the Bloomfield Sandstone at the top of the middle division or variegated shale of the fifth group of Rogers. This fifth group of the Pennsylvanian Survey immediately underlies the Water-lime, corresponding to the English Lower Ludlow, and has been shown by the writer to represent the Onondaga shale of New York. The position of the latter in the series is shown by the following sections taken from Prof. James Hall:—

NEW YORK.	GREAT BRITAIN.
Lower Helderberg	Wanting.
Water-lime	Lesmahago beds.
Onondaga salt group	Wanting.
Niagara group	Wenlock Limestone.

The last two were considered representative by Sir R. Murchison, and this view has never been disputed.

It therefore appears that the Pennsylvanian Pteraspids from the Bloomfield Sandstone are older than *Scaphaspis ludensis* of the Lower Ludlow by the time required for the deposition of 200 feet of strata. But 1000 feet below the horizon just named comminuted fish-scales are found in beds containing *Leperditia alta*; and again, 700 feet lower, in the iron sandstone near the middle of the Clinton group, which corresponds to the English Upper Llandovery beds; and 200 feet below the Ore Sand-rock, broken plates, with the superficial striation of *Palæaspis* and a few fine spines of *Onchus* (described as *O. Clintoni*) are met with. The horizon is well defined, for the Ore Sand-rock contains *Beyrichia lata*, *Calymene Clintoni*, *Ormoceras vertebratum*, and other characteristic fossils. The iron sandstone also contains white pellets, apparently of coprolitic origin, and containing 32 per cent. of phosphate of lime.

Previously reported discoveries of fish in American Silurian rocks were discussed, and their supposed age shown to be erroneous. The paper concluded with the description of two species of *Palæaspis* (*P. americana* and *P. bitruncata*), of *Onchus Pennsylvanicus* from the Bloomfield Sandstone, Onondaga group, and of *Onchus Clintoni* from the Iron Sandstone of the Clinton group.

3. "On some West-Indian Phosphate Deposits." By George Hughes, Esq., F.C.S. (communicated by W. T. Blanford, Esq., LL.D., F.R.S., Sec. G.S.)

Some West-Indian specimens of phosphates were exhibited, in reference to which the author called attention to a description by Dana of an instance in which the carbonate of lime in fragments of coral was partially converted into phosphate, and also to the apparent alteration of limestone rock into phosphate of lime in Barbuda Island by the action of water draining a guano-like deposit of bats' dung in a cave. A specimen of the phosphate of lime thus produced was exhibited.

In Aruba Island the process of conversion of coral-rock into phosphate of lime has been in operation on so extensive a scale that the deposit is being largely worked for shipment. The alteration is probably due to the action of water containing soluble phosphates derived from the excrements of sea-birds (guano). Of this guano no trace remains; but the fragments of coral in the underlying rock have been altered into a substance containing 78 to 80 per cent. of phosphate of lime; and the deposit, as shipped, contains 35·7 per cent. of phosphoric acid, equal to 77·9 per cent. of tribasic phosphate.

Reference was also made to some other West-Indian phosphate-deposits formed of bones, and to iron and alumina phosphates found in Redonda, Alta Vela, and Testigos Islands.

4. "Notes on species of *Phyllopora* and *Thamniscus* from the Lower Silurian Rocks, near Welshpool, Wales." By George Robert Vine, Esq. (Communicated by Prof. P. Martin Duncan, F.R.S., F.G.S.)

In this paper a species of *Phyllopora* from the Caradoc beds of

Wern-y-scadog, Llanfyllin, was described as *P. tumida*, and a *Thamniscus* from the volcanic ash of Middleton Hill, near Welshpool, probably of Bala age, as *T. antiquus*, both from a collection sent by Mr. J. B. Morgan, of Welshpool, to Prof. Lapworth for identification. A list of the species of *Phyllopora*, hitherto described from Lower-Silurian beds, and of both Upper and Lower Silurian forms of *Thamniscus*, was added, and the relations of the various known species to those described in the present paper were discussed at some length.

CORRESPONDENCE.

FULLERS EARTH AND WATER SUPPLY.

Sir,—At Woburn, Beds, the Fullers earth is obtained by digging cylindrical holes or wells, as they are there called, in the Greensand, until this marl is reached. Sometimes there is water, oftener not; but when there is, it is the finest and sweetest in the country, very clear, never failing, but not very abundant. So good is it that those domestic wells deriving their supply from some other source than the Fullers earth, are treated to it, from time to time artificially, by having masses of it placed in them. The cleansing properties of this 'earth,' as applied to blankets, etc., is universally recognized, but I never heard before of its being used for cleansing water supply. I understand, however, that such is the case, the Woburn earth having been sent into a neighbouring county for that purpose; though I have not as yet been able to obtain corroboration of this, nor to find out whether it is put into filter beds with the other material, or in what way it is made use of. A. G. Cameron.

H.M. Geological Survey, Bedford.

THE PHENOMENA OF STRAINS, Etc., OBSERVABLE IN OBSIDIAN.

Sir,—In the August number of the Quarterly Journal of the Geological Society, Mr. F. Rutley describes the phenomena of strain in the glass of some obsidians around embedded crystals. I enclose a photograph of similar depolarizing effects in a slide, cut from a specimen of Mexican obsidian given to me some years ago by my friend Mr. J. Backhouse of York, among a number of pieces several of which showed the phenomenon in question.

It is rather remarkable that in the same slide some of the crystals exhibit the luminous brushes as described and figured in the article cited, while others apparently have no effect upon the state of the glass. This is the case round both the crystals of felspar of various kinds, and the black specks, mostly rounded, which I suppose are magnetite.

I determined that the glass is compressed by observing the effects produced by the interposition of different parts of a strip of glass between the slide and the objective when bent by the pressure of the fingers in a horizontal plane. By this means it was possible to so compensate the effect, that at any point of the luminous brushes darkness could be restored; and this was found to be the case when the stretched part of the glass strip was superposed. On the other hand, either pair of the quadrants could be brightened by placing the length of the glass corresponding with their direction and bringing the *compressed* side into action. The effects are still more marked when a selenite is used, but disappear entirely on inserting a quartz plate until the analyser is somewhat rotated.

In one case I have met with appearances quite the reverse of those described by Rutley in the case of perlitic cracks. One of these surrounds a crystal to the extent of about ⅔, and *within* this the field is dark, while the line of the crack is fringed with light due to pressure in the glass surrounding the pearl. Connected with this encircling crack, although, owing to the thickness of the section, the connection is not very definitely traceable, is a long straight crack extending both ways from the crystal. At the extreme points of this the brushes reappear, and when the crack is parallel to the principal plane of either of the Nicols prisms, they are quite brilliant. We have here evidently the expression of the rending force which at this point was not able actually to separate the particles of the glass, but only to produce the strain which results in depolarization.

The connection which Mr. Rutley suggests between strain and crystallization is, I think, scarcely available here, as the glass is compressed, and the phenomena seem to me rather to point to a higher coefficient of expansion by heat for the obsidian glass than for felspar and magnetite producing in the former, since it was fitted, so to speak, to the crystal at a high temperature, a strain similar to that of an iron tire shrunk on the woodwork of a wheel. If any data of the expansions of the substances involved are known it would be easy to test this, but I do not know where to find any.

BIRMINGHAM. THOS. H. WALLER.

POSIDONOMYA BECHERI.[1]

SIR,—I have just seen in your interesting article in the last Number of the GEOLOGICAL MAGAZINE, "On the Discovery of Trilobites in the Culm Shales of Devonshire," a reference (on p. 540) to the occurrence of *Posidonomya Becheri* in the rocks at Budle, Northumberland. Please allow me to point out that this shell was found there by Sir Roderick Murchison and others, many years ago (see p. 291, Siluria, 4th edition), and the late Mr. G. Tate, of Alnwick, has noticed its presence here along with many well-known Carboniferous limestone fossils, *eg. Griffithides, Bellerophon, Unio, Euomphalus, Chonetes, Hardrensis,* etc. (Trans. Ber. Nat. Club. vol. v. p. 73, 1863). I never heard till now that any one regarded these beds as "Tuedian." They are underlain and entirely surrounded by beds of the ordinary Carboniferous Limestone type, and there is no Tuedian within many miles of them. If the *Posidonomya Becheri* is characteristic of genuine Tuedian, why is it not shown to occur abundantly in Northumberland in all the beds which everybody admits to be Tuedian or Lower Carboniferous? Almost all the Carboniferous Limestone of North Northumberland is the representative of Phillips's Yoredale Series, and I have no doubt the Budle Beds are much nearer to the top than the bottom of the Carboniferous Limestone Series. In Ireland the *Posidonomya* is a characteristic fossil of certain black shales lying above the Carboniferous Limestone, which were at one time regarded as Coal-measures, but which are probably the representatives of the Yoredale Beds of England (see Jukes's Manual, 3rd edition, pp. 591-2). I hope soon to show that the Tuedian Beds and the Calciferous Sandstone of Scotland represent in time not only the Lower Limestone Shale, but the greater part of the Carboniferous Limestone also.

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[1] See *ante*, pp. 73-76.

20, Cumberland Street, W. Gunn.
Edinburgh, *Dec.* 20, 1884.

OBITUARY.

DR. THOMAS WRIGHT, F.R.S., F.R.S.E., F.G.S.

Dr. Thomas Wright was born in Paisley, Renfrewshire, N. B., November 9th, 1809. He was educated at the Paisley Grammar School, and before he completed its curriculum, was articled to his brother-in-law, a surgeon and general practitioner, where he acquired an elementary knowledge of the Natural Sciences, and showed an early predilection for biological studies.

Before the expiration of his articles his brother-in-law removed to a practice in Ayrshire, which occasioned an interruption to his course of study, and temporarily disarranged his pursuits. After a futile attempt to enter into a manufactory, for which his scientific tastes rendered him quite unfit, he rejoined his brother-in-law, and having completed his articles, prepared himself for entering the medical classes of the University of Glasgow. But acting upon the advice of his friends, he proceeded to Ireland, and enrolled himself as an anatomical student in the Royal College of Surgeons, Dublin, where he rapidly acquired an extensive knowledge of anatomy, and became an accomplished physiologist and pathologist. Later on he was induced to study under Messrs. Kirby and Ellis, and soon became their Assistant-demonstrator. On leaving Dublin he received the highest credentials from those gentlemen, and was offered the post of Demonstrator of their School, with the promise of the Chair of Anatomy and Physiology if he remained.

During the preceding winter, however, Dr. Wright had suffered much from a dissecting wound which quite unfitted him for anatomical work, and compelled him to decline the offer so handsomely made by Mr. Ellis. On recovering his health, he passed the College of Surgeons, London, in 1832. and graduated as M.D., at St. Andrew's University in 1846. Soon after passing the College he settled in Cheltenham, where his life has since been spent in the active practice of his profession. He was for fifteen years Surgeon to the Cheltenham

Dispensary, for upwards of twenty years Surgeon to the General Hospital; and for many years President of the Literary and Philosophical Association, during which period he delivered, in different sessions, courses of lectures on Comparative Physiology, Natural History, and Palæontology.

Dr. Wright strongly advocated the teaching of Natural Science in colleges and schools, and was always ready to help in the cause of popular education. He frequently lectured in Bristol, Bath, Worcester, and elsewhere, on scientific subjects which he made his life-long study. During the early days of his professional career he devoted much time to microscopical research, but his eyesight suffering from too close an application to these investigations, he turned his attention to Palæontology, in the pursuit of which the Oolitic rocks of the Cotteswold Hills around Cheltenham afford such rich materials. He made in his leisure hours a large collection of fossil Echinoderms from these and other Oolitic formations, and read a series of Memoirs to the Cotteswold Field Club on the minute anatomy of this class, which appeared in the Annals and Magazine of Natural History. These papers attracted the attention of Professor Edward Forbes, F.R.S., who spoke in high terms of their merit, and proposed to Dr. Wright that they should publish a joint Monograph on the British Fossil Echinodermata for the Palæontographical Society. It was finally settled that Professor Forbes should describe and figure the British Cretaceous and Tertiary species, and that Dr. Wright should describe and figure the Oolitic forms. But that accomplished Naturalist died, just when he had obtained the ambition of his life, the chair of Natural History in the University of Edinburgh, and before he had done anything to his portion of the work; so that on the completion of the Monograph on the Oolitic Echinidæ, and the Monograph on Oolitic Asteriadæ and Ophiuridæ, the Council of the Palæontographical Society requested Dr. Wright to undertake that part of the work which Edward Forbes had left unfinished. Dr. Wright commenced (in 1860) the description, with figures, of all the Cretaceous species, and for more than twenty years he devoted all his leisure to this work, which is now completed, and forms a large volume of 390 pages quarto, with 87 magnificent plates.

In 1875 Dr. Wright commenced another extensive Monograph on the "Lias Ammonites of the British Isles." He had been collecting materials for this work during his long residence in Cheltenham; and had succeeded in securing a rare and beautiful series of these Cephalopods, many of his specimens having been carefully and judiciously selected to show the remarkable morphological changes through which Ammonites pass in the process of their evolution. This work, happily now completed, consists of 480 pages of text and 90 plates. His palæontographical labours fill four large quarto volumes, and comprise 242 plates, accompanied by 1568 pages of descriptive letterpress, every species having a full detailed description given of the form, with its affinities and differences from congeneric species carefully pointed out, also the locality from whence it was derived, and its stratigraphical distribution accurately defined, both in English and Continental rocks. These works have occupied all his leisure hours for the last thirty years. Much of this time was devoted to the collection of specimens, the examination of private cabinets and those in British and foreign museums, in order to compare all the British species with continental forms, and thus to bring each one to the crucial test of a critical and personal examination. He made many journeys to the Continent to visit the grand collections in Paris, Stuttgart, and Tübingen in Germany, and those in the Geneva Museum, and in that of Zurich, Switzerland. The accomplishment of this self-imposed task has been the pleasure and delight of his life. For these works, and other memoirs on geology published in the Quarterly Journal, the Council of the Geological Society awarded him the Wollaston Medal in 1878.

Dr. Wright was elected a Fellow of the Royal Society of Edinburgh in 1855, a Fellow of the Geological Society in 1859, and a Fellow of the Royal Society of London in 1879. For many years he filled the post of Medical Officer of Health for Cheltenham, Charlton Kings, and Leckhampton.

Referring to the sad losses which our science sustained at the close of 1884, in the deaths of Mr. Godwin-Austen; Dr. Wright; Prof. James Buckman; Mr. Alfred Tylor; and Mr. Searles V. Wood; all of them Fellows of the Geological Society, Prof. Edward Hull, F.R.S., writes:—"Dr. Wright was one of that small band of local geologists, who, like Charles Moore of Bath; Dr. Lycett of Minchinhampton; G. W. Ormerod of Cheshire; and Edward Binney of Manchester; have made their respective habitats, to use a scientific term, as household words amongst geologists, and have largely contributed to the general advancement of our knowledge of Natural History."

The following is a List of his Geological Papers and Monographs:—

A Stratigraphical Account of the Sections from Round Tower Point to Alum Bay, on the N.W. Coast of the Isle of Wight. Ann. Mag. Hist. 1851, vol. vii. pp. 14-27; Cotswold Club Proc. 1853, vol. i. pp. 87-100.

On the *Strombidæ* of the Oolites (with the description of a new and remarkable *Pterocerus*, by John Lycett). Ann. and Mag. Nat. Hist. vol. vii. pp. 306-310; Cotswold Club Proc. 1853, vol. i. pp. 115-119.

A Stratigraphical Account of the Sections of Hordwell Beacon, and Barton Cliffs, on the Coast of Hampshire. Ann. and Mag. Nat. Hist. 1851, vol. vii. pp. 433-446; Cotswold Club Proc. 1853, vol. i. pp. 120-133.

On the *Cidaridæ* of the Oolites, with a Description of some New Species of that Family. Ann. and Mag. Nat. Hist. 1851, vol. viii. pp. 241-280; Cotswold Club Proc. 1853, vol. i. pp. 134-173.

On the *Cassidulidæ* of the Oolites, with Descriptions of some New Species of that Family. Ann. and Mag. Nat. Hist. 1852, vol. ix. pp. 81-103, 206-214, 294-316; Cotswold Club Proc. 1853, vol. i. pp. 174-226.

Contributions to the Palæontology of the Isle of Wight. Ann. and Mag. Nat. Hist. 1852, vol. x. pp. 87-93; Cotswold Club Proc. 1853, vol. i. pp. 229-234.

Contributions to the Palæontology of Gloucestershire. A Description of some New Species of Echinodermata from the Lias and Oolites. Ann. and Mag. Nat. Hist. 1854, pp. 161-173, 312-324, 376-383; Cotswold Club Proc. 1860, vol. ii. pp. 17-48.

On Fossil Echinoderms from the Island of Malta, with Notes on the Stratigraphical Distribution of the Fossil Organisms in the Maltese Beds. Ann. and Mag. Nat. Hist. 1855, vol. xv. pp. 101-127, 175-196, 262-277; Cotswold Club Proc. 1860, vol. ii. pp. 124-127.

On a New Genus of Fossil *Cidaridæ*, with a Synopsis of the Species included therein. Ann. and Mag. Nat. Hist. 1855, vol. xvi. pp. 94-100.

On some New Species of *Hemipedina* from the Oolites. Ann. and Mag. Nat. Hist. 1855, vol. xvi. pp. 196-199; Cotswold Club Proc. 1860, vol. ii. pp. 125-130.

On the Occurrence of Upper Lias Ammonites in the (so-called) Basement-Beds of the Inferior Oolite. Brit. Assoc. Rept. 1856 (pt. 2), pp. 80-82.

On the Stratigraphical Distribution of the Oolitic Echinodermata. Brit. Assoc. Rept. 1856, pp. 396-404.

On the Palæontological and Stratigraphical Relations of the so-called "Sands of the Inferior Oolite." Quart. Journ. Geol. Soc. 1856, vol. xii. pp. 292-325.

Notes on the Fossils collected by Mr. Geikie from the Lias of the Isles of Pabba, Scalpa, and Skye. Quart. Journ. Geol. Soc. 1858, pp. 24-36.

On the *Avicula contorta* Beds and Lower Lias in the South of England. Brit. Assoc. Rept. 1860 (pt. 2), p. 108; Quart. Journ. Geol. Soc. 1860, vol. xvi. pp. 374-411.

Remarks on the "Roadstones" of Cleeve-Hill. Cotswold Club Proc. 1860, vol. ii. pp 184-187.

On the Subdivisions of the Inferior Oolite in the South of England, compared with the equivalent Beds of that Formation on the Yorkshire Coast. Quart. Journ. Geol. Soc. 1860, vol. xvi. pp. 1-48.

Geological Expedition to Swift's Hill and Rodborough (1860). Cotswold Club Proc. 1865, vol. iii. p. 21.

The Oolitic Section at Leckhampton (1860). Cotswold Club Proc. 1865, vol. iii. pp. 26-52.

Report on Miss Holland's Collection of Lias Fossils (1862). Cotswold Club Proc. 1865, vol. iii. pp. 153-156.

On the Ammonites of the Lias Formation. Cotswold Club Proc. 1865, vol. iii. pp. 162-179, 235-245.

On the Development of Ammonites Brit. Assoc. Rept. 1864 (Sect.), vol. xxxiv. pp 73-74; GEOL. MAG. 1865, Vol. II. pp. 86-87.

On the White Lias of Dorsetshire. Brit. Assoc. Rept. 1864 (Sect.), vol. xxxiv. p. 75; GEOL. MAG. 1864, Vol. I. pp. 290-292.

On the Fossil *Echinidæ* of Malta (1863). Quart. Journ. Geol. Soc. 1864, vol. xx. pp. 474-489.

Table of the Stratigraphical Distribution of the Echinoderms of Malta (1863). Quart. Journ. Geol. Soc. 1864, vol. xx. p. 490.

Additional Notes on Cleeve-Hill Section (1865). Cotswold Club Proc. 1868, vol. iv. pp. 60-70.

On Coral Reefs, Present and Past. Cotswold Club Proc. 1868, vol. iv. pp. 97-173.

Notes on a New Species of Starfish from the Ironstone Beds of the Inferior Oolite of Northamptonshire. Quart. Journ. Geol. Soc. 1870, vol. xxvi. pp. 391-393.

On the Geological Features of the Country round Ross. Woolhope Field Club Trans. 1870, pp. 45-50.

On the Coralline Formations of the Oolitic Rocks. Woolhope Field Club Trans. 1870, pp. 52-53.

On the Correlation of the Jurassic Rocks, in the Department of the Côte-d'Or, France, with the Oolitic Formations in the Counties of Gloucester and Wilts, England (1870). Cotswold Club Proc. 1872, vol. v. pp. 143-238; GEOL. MAG. 1870, Vol. VII. pp. 568-571.

On a New Genus of Silurian *Asteriadæ*. Quart. Journ. Geol. Soc. 1873, vol. xxix. p. 421.

MONOGRAPHS PUBLISHED BY THE PALÆONTOGRAPHICAL SOCIETY.

Fossil Oolitic Echinodermata, vols. i. and ii., 1855-80, 65 plates, pp. 698.
Fossil Cretaceous Echinodermata, vol. i. 1864-82, 87 plates, pp. 390.
Liassic Ammonitidæ, vol. i. 1878-84, 90 plates, pp. 480.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. II.

No. III.—MARCH, 1885.

ORIGINAL ARTICLES.

I.—ON THE CLOSE OF THE HIGHLAND CONTROVERSY.

By Professor CHARLES LAPWORTH, LL.D., F.G.S.;
Mason Science College, Birmingham.

ALL those British geologists who have interested themselves in the long-vexed question of the geological position and true mode of origin of the Metamorphic rocks of the Highlands of Scotland must have read with the greatest interest and pleasure the clear and vivid "Report on the Geology of the North-West of Sutherland," by Messrs. Peach and Horne, in the pages of "Nature"[1] for November last; and the manly and candid Introductory Observations by the Director-General of the Geological Survey. Not only does the publication of this Report put an end to one of the most keenly agitated controversies in the history of British Geology, but it explains and harmonizes the diverse views of the contending parties. The issue appears to me to be most creditable to all concerned. For many years the Highland controversy has appeared to outsiders, and to those geologists who were unaware of the difficulties attending the stratigraphy of the older rocks, as a trivial dispute between the Geological Survey on the one hand and a few misguided amateurs on the other. So simple and so irresistible appeared to be the facts and arguments advanced by Sir Roderick Murchison and his followers in proof of a naturally conformable upward succession from the unaltered Silurian rocks of the North-West into the overlying metamorphic rocks of the Highlands, that they carried conviction to the minds of geologists of the first rank, from Lyell downwards. So overwhelming indeed was the concensus of opinion in favour of the general accuracy of Murchison's conclusions, that those geologists, who have so strongly denounced and so steadily endeavoured to disprove it, have had by no means an easy or a pleasurable task. That they committed some mistakes and drew some erroneous conclusions during the prosecution of their investigations was inevitable, from the very novelty of the work, and the complicated nature of the stratigraphy. But when these mistakes are set off against the gigantic error which these investigators so successfully opposed, there will be found to be a most substantial balance in their favour, for which the future student of these old rocks will give them due credit.

The story of the origin, the publication and the extraordinary success of the Murchisonian hypothesis of the Highland sequence, in spite of the manly opposition of Nicol; and of the labours, the discoveries, and the conclusions of its opponents, from the date of the bold re-opening of the controversy by Dr. Hicks, down to the issue of the report of Messrs. Peach and Horne, will form a most interesting and instructive chapter in the history of British Geology. It is to be hoped that some geologist, who is familiar with all the facts, and has not identified himself with either of the contending parties, will write this story for the information and edification of our scientific public in general, while the subject is still fresh in the minds of all.

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[1] Nature, 1884, vol. xxxi. p. 29.

By myself, the Murchisonian hypothesis has been objected to upon two grounds: *first*, because I believed that the assumed stratigraphical proofs upon which it was founded were erroneous, and that their general acceptance delayed the discovery of the true laws of the stratigraphy of the older convoluted rocks; *second*, because the supposed ascending succession in the North-West seemed to shut up geologists in general to a theory of regional metamorphism, which I regarded as impossible and absurd. Some of my ideas respecting the worthlessness of Murchison's stratigraphical evidences, were published in the first part of my uncompleted paper on the "Secret of the Highlands," together with a short sketch of the stratigraphical phenomena that might reasonably be expected in these mountain regions.[1] The actual stratigraphy of the more important parts of the Durness-Eriboll district, and a sketch of the probable agency and mode of metamorphism of its schists, I trusted to be able to develope in the final parts of that paper; but a severe illness contracted by myself in working out the rocks in the North-West has prevented the execution of this task. Indeed, there is now no longer any absolute necessity for its completion, for the conclusions at which I arrived seem to me to be identical in all their essentials with those recently published by Messrs. Peach and Horne.

A brief summary of my own results in so far as they affect the age, composition, and mode of formation of the eastern schists, as deduced from the remarkable stratigraphical and metamorphic phenomena apparent in Durness and Eriboll, will be found in the brief communication printed in the appendix to these remarks. It was written mainly to show the difference between my own views and the views of those, on the one hand, who believed in the Archæan age of all the Eastern metamorphic rocks, and of those, on the other, who held that because the Durness Limestone was succeeded, with apparent conformity, by the metamorphic schists in Sango Bay, the latter were geologically newer. It was read on my behalf by my friend Mr. J. H. Teall at the ordinary meeting of the Geologists' Association on the 4th of July last, and is here reprinted, from an advanced proof, by the kind permission of the Council of the Association. It is not referred to in this place, as establishing any selfish claim to priority, for the officers of the Survey reached their conclusions in complete ignorance of my results, and from a totally different direction, while they have gone far beyond me in working out the details of the subject. Should there be, however, any stray geologists who still hesitate to accept the statements of Messrs. Peach and Horne respecting the extraordinary nature of the stratigraphical phenomena in our British mountain region, and fail to appreciate the brilliant light thus thrown upon the true mode of origin of some of the crystalline schists, it may aid them in arriving at a correct opinion to note for themselves how two sets of investigators, coming to the Durness-Eriboll district with theoretical views almost diametrically opposed to each other, have independently arrived at, and independently made known, the same general conclusions, as regards (1) the sequence; (2) the extraordinary stratigraphical phenomena; (3) the mode of metamorphism; (4) its Post-Cambrian date.

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[1] See GEOL. MAG. Decade II. Vol. X. 1883, pp. 120, 193, and 337.

We are now for the first time in a position to take stock, as it were, of the common acquisitions of all parties on the subjects of the stratigraphy and metamorphism of the rocks of the North-West Highlands. The more vital conclusions laid down in the Report of Messrs. Peach and Horne, or incidentally covered by it, are summarized below. It will be apparent on testing the references given (which include merely a single citation for the different investigators in each case) that they are in thorough accord with similar conclusions arrived at by one or by many of the opponents of the Murchisonian hypothesis, a circumstance which affords a strong presumption of their general correctness, and a high probability that they will soon be accepted by all.

Synopsis of our present ideas of the Geology of the Rocks of the North-West Highlands.

(*a*) THE SEQUENCE.

1. The unaltered Palæozoic rocks of North-west Sutherland and Ross consist of four[1] main members—the Torridon Sandstone, the Quartzite, the Fucoid Group, and the Durness Limestone.
2. These major groups admit of subdivision into several recognizable zones,[2] capable of being easily identified upon the ground.
3. The Durness-Eriboll Limestone is the newest sedimentary rock[3] in the district.
4. The Upper Quartzite and Upper Limestone of Murchison are non-existent;[4] the so-called Upper Quartzite is the Lower Quartzite repeated, and the so-called Upper Limestone is in reality a repetition of a part of the Durness Limestone itself.

(*b*) THE STRATIGRAPHY.

5. There is no[5] conformable upward succession, as held by Murchison and his followers, from the Silurian Rocks into the Eastern Gneissic series; for—

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[1] Nicol, Quart. Journ. Geol. Soc. 1856, p. 20, etc. Hicks, Q.J.G.S. 1878, p. 813. Callaway, Q.J.G.S. 1883, p. 358, etc. Lapworth, GEOL. MAG. 1883, p. 123, etc.

[2] Lapworth, GEOL. MAG. 1883, p. 126, etc. Callaway, Q.J.G.S. 1883, p. 358, etc.

[3] Nicol, Q.J.G.S. 1861, p. 88, etc. Callaway, Q.J.G.S. 1881, p. 244. Lapworth, GEOL. MAG. 1883, p. 127.

[4] Nicol, Q.J.G.S. 1861, p. 91, etc. Hudleston, GEOL. MAG. 1882, p. 394. Lapworth, GEOL. MAG. 1883, p. 127. Callaway, Q.J.G.S. 1883, p. 367.

[5] Nicol, Q.J.G.S. 1861, p. 86. Hicks, *ibid.* 1883, p. 157. Callaway, Q.J.G.S. 1883, p. 357. Lapworth, GEOL. MAG. 1883, p. 127.

6. In some spots the basement beds of the local Palæozoic rocks rest unconformably[1] upon one member of the Eastern metamorphic series: while—
7. Generally speaking, the line of junction of the unaltered Palæozoic rocks and the Eastern Metamorphic Series is a great fault[2] and overthrust, along which—
8. The Eastern metamorphic series has been forced[3] over the Silurian rocks by Earth-movements which have acted since Lower Silurian (Ordovician) times.
9. The schists and gneisses of Sango Bay and Farrid Head, which repose locally upon the Durness Limestones, do not form part of a continuous sedimentary succession. They are a part of the Eastern or Upper Gneissic Series, and they are separated from the Durness Limestone by planes of fault.[4]
10. As these schists, etc., of Sango Bay are similar in character and arrangement to the zones of pressure schists occurring above the great overthrust in Eriboll,[5] nearly 10 miles to the S.E. they afford a rough index of the enormous distance to which the metamorphic rocks have been forced over the underlying sedimentary and unaltered deposits.
11. Much of the Eastern Gneiss is merely the Archæan[6] gneiss repeated; the Logan Rock of the Assynt district is generally the Archæan[7] brought up from below the overlying sedimentaries, and the Arnaboll Rock of Eriboll[8] is a part of the same Archæan (Hebridean) gneiss.

(*c*) THE METAMORPHISM.

12. The petrological, lithological, and mineralogical distinctions between the Hebridean gneiss and the Logan[9] and Arnaboll Rocks and their equivalents are primarily due to the extraordinary mechanical disturbances[10] to which the latter have been subjected.
13. The planes of schistosity in the Eastern Metamorphic Schists, etc., between and above the great fault-planes, are not planes of bedding:[11] they are planes of shearing and cleavage, gliding planes (thrust-planes) along which the rocks have yielded to the lateral crust-pressure.

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[1] Lapworth, GEOL. MAG. 1883, p. 127. Callaway, Q.J.G.S. 1883, p. 407. Compare Hicks, 1880, GEOL. MAG. p. 21.

[2] Nicol, Q.J.G.S. 1861, p. 86. Callaway, Q.J.G.S. 1883, p. 357, etc. Hicks, Q.J.G.S. 1883, p. 157. Lapworth, Q.J.G.S. 1883, p. 421.

[3] Callaway, Q.J.G.S. 1883, p. 410. Lapworth, *loc. cit.* Compare Nicol, Q.J.G.S. 1861, p. 110, and Hicks, GEOL. MAG. 1880, p. 17.

[4] Nicol, Q.J.G.S. 1861, pp. 87, 88. Callaway, *ibid.* 1881, p. 241. Lapworth, see Appendix.

[5] Lapworth, 1884, see Appendix, p. 104.

[6] Nicol, Q.J.G.S. 1861, p. 95. Hicks, *ibid.* 1878, p. 818, etc. etc.

[7] Bonney, Hudleston, Proc. Geol. Assoc. 1879, p. 75; Q.J.G.S. 1880, p. 95. Callaway, *ibid.* 1883, p. 410.

[8] Lapworth, Q.J.G.S. 1883, p. 422, etc.

[9] Compare Bonney, Q.J.G.S. 1880, p. 95, etc.

[10] Lapworth, 1884. see Appendix, p. 103.

[11] Lapworth, 1884, *loc. cit.* Compare also Bonney, Q.J.G.S. 1883, p. 415, etc.

14. By the agency of this lateral earth-thrust, the Archæan, the plutonic, and included patches of sedimentary rocks have been locally sheared and flattened out into rocks resembling hälleflintas[1] and rhyolites, even finely-laminated shales.
15. This Eastern Metamorphic Series of Sutherland and Ross not only contains Archæan rocks, but also local patches of metamorphosed Palæozoic,[2] intrusive, and segregatory rocks, together with local patches of material probably compounded of all these in different degrees.[3]
16. This Eastern Metamorphic Series has received its present strike, pseudo-bedding and its present foliated and mineralogical characteristics through the agency of the crust movements which have operated within the district since Lower Silurian times.[4]

Some of these conclusions may appear startling at first sight to those who have not followed with interest and appreciation the more recent developments of our knowledge of the geological phenomena of mountain districts. But they agree precisely with the results which have been already worked out by extra-British investigators. The stratigraphy of the North-West Highlands, as I have more than once suggested, is precisely of the same character as that so admirably described and illustrated by Heim[5] in his magnificent work upon the Alps of Central Switzerland. The metamorphic phenomena of the north-west, too, are identical with those so minutely detailed and photographed in Lehmann's most valuable work on the metamorphic rocks of the Saxon[6] Erzgebirge. Continental geologists, British amateurs, and the officers of the Geological Survey are now at one and the same point. They stand together on the shore of a new world of geological discovery, full of the richest promise.

But it must not be forgotten that the results already attained in the north-west are merely the preliminary sketches for a great and a most necessary work, namely, the detection of the chief laws of mountain stratigraphy and the discovery of the more important processes of regional metamorphism. Investigators are certain to crowd in hosts to the new ground in search of fresh discoveries, and geological pamphlets upon the district will soon be thick as leaves in Vallambrosa. All this will advance the science greatly, and much good will come of it. But before we can advance far beyond our present standpoint, it is absolutely requisite that the debatable region shall be accurately mapped and its complicated stratigraphy unravelled. This is a work which can only be accomplished speedily and in its entirety by the Geological Survey. And it is a preliminary and necessary work of the very first importance, for upon its speedy and satisfactory completion hang some of the most vital problems in British stratigraphical as well as in general theoretical geology.

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[1] Lapworth, *loc. cit.* 1884.
[2] Compare Hicks, 1883, Q.J.G.S. p. 147.
[3] Lapworth, 1884, *ibid.* p. 104.
[4] Lapworth, 1884, *ibid.* p. 105.
[5] Heim, *Mechanismus der Gebirgsbildung*, Basel, 1878.
[6] Lehmann, *Entstehung der Altkrystallinischen Schiefergesteine*, Bonn, 1884.

By means of their recent labours in the Durness-Eriboll district Messrs. Peach and Horne have familiarized themselves with the minutest details of its component formations, and have studied and interpreted its astounding stratigraphical phenomena in the area where they are most completely dissected by nature for the benefit of the investigator. No one who has the real interest of geology at heart but will earnestly hope and trust that they will uninterruptedly continue the work they have so excellently begun until it is thoroughly complete from Eriboll to Skye.

May we soon see a Monograph upon the debatable land of the North-West, that shall compare with those fine works issued by the American Survey, and shall demonstrate both to our scientists and to the educated public at large that the members of our British Survey can not only lay down correctly upon their maps the true places of the economic treasures of the rocky floor of our country, but that they can interpret minutely and correctly the most complicated geological phenomena of our mountain regions!

But a work of this kind need not clash in the slightest degree with the contemporaneous work of amateurs in the same or in corresponding fields of research. The subject is perfectly free and open to all. Every investigator has a right to address himself to any part of the work he pleases, and the right, if he deems it fitting to exercise it, to demand a full recognition of the importance of his own contribution to the common stock of discovery. No investigator, or body of investigators, has any claim, beyond that conceded by courtesy, to a monopoly in any special department of geology, local or theoretical. The only available geological possessions of the investigator are his abilities, his opportunities, and the fruits of the good work he has done in the past. The only authority he dare recognize with safety is Nature herself. The extremest penalty for the slightest departure from the course she has marked out, whether committed wilfully or in ignorance, will be mercilessly exacted by her tardy but sure-footed avenger—Time.

It seems to me that these are the conclusions that every one who knows the facts is certain to draw for himself, from the startling and sudden collapse of the brave Murchisonian hypothesis in our midst, and that they ought to have the effect of banishing partisanship, and of teaching us scientific toleration and mutual respect.

At the present time the several groups of students of these old rocks are all met together upon one and the same elevated platform of a common opinion, having climbed up painfully thereto from many different directions. The old subject of dispute has utterly disappeared, and there is no longer any reasonable excuse for dissension. We have all been partly right and partly wrong. It is a time for a hearty laugh all round, a time to shake hands and be friends.

The inauguration of the Murchisonian hypothesis of the Highland succession marked the beginning in Britain of a period of bitter controversy, of estrangement of Survey men and amateurs, of decline in geological enthusiasm, and of comparative feebleness of geological research. Let us trust that its downfall marks the commencement of a new and a happier period like that of the earlier years of the present century, when all British geologists shall meet upon an equal footing, in mutual communion and sympathy, and when the only rivalry between parties shall be in vieing with each other in developing the unknown treasures in that new geological world of wonder now opening up before our eyes, where authority and precedent are alike unknown, and where so much awaits discovery that there is room and work and hope for all.

APPENDIX.

ON THE STRATIGRAPHY AND METAMORPHISM OF THE ROCKS OF THE DURNESS-ERIBOLL DISTRICT.[1]

By CHARLES LAPWORTH, LL.D., F.G.S.,
Professor of Geology and Mineralogy, Mason Science College, Birmingham.

In[2] the district round Eriboll and Durness, the so-called Eastern (or Upper) Gneiss is composed of two very distinct members. The older member is the Arnaboll Gneiss, which is, in my opinion, nothing more nor less than the so-called Laurentian (or Lower Gneiss) brought up to the east of the Assynt (Durness-Eriboll) series by gigantic overfolds.

The younger member, which is composed of the schistose metamorphic rocks of the Moen and Central Sutherland, contains within it—forming almost inseparable parts of its mass—long strips and patches of the lower zones of the Assynt (Durness-Eriboll) series. The schistose quartzites or the quartz-schists (of some authors) of the Sutherland Schist Series are actually nothing more than the crushed and mechanically metamorphosed ends of long wedges of the Assynt Series, and are often in visible continuity upon the ground with the unaltered Assynt beds.

I hold that the Sutherland Schistose Series is composed of a complete intermixture of Archæan and Assynt rocks, the two series being so interfolded and interfelted together that (exception being made of those zones near the great overfaults where the metamorphism is incomplete) they can never be separated in the field, but must be mapped simply as "metamorphic."

The planes of foliation and schistosity in the (so-called) Upper Metamorphic Series of Sutherland are not planes of bedding; they are planes of cleavage—that is, gliding-planes, along which the rocks have yielded to the irresistible pressure of the lateral Earth-creep during the process of mountain-making. This pressure was so extraordinary that granites, syenites, pegmatites, gneisses, and quartzites have been crushed to powder, and have been finally flattened out into rocks having all the external characters of hälleflintas and even finely laminated shales. Every stage of the crushing process is recognizable in the field and under the microscope, from the coarsest pegmatite and gneiss down to the so-called metamorphic shales, schists, and slates. Hence the most highly metamorphosed rocks of Eriboll are not the coarse Hebridean Gneisses, but the fine slaty schists.

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[1] Read at Ordinary Meeting of Geologists' Association, July 4th, 1884.

[2] The communication is printed as read. A few words have been added by Prof. Lapworth for the sake of clearness of description. These are given in brackets.—J. J. H. TEALL.

The process of rock-folding in the region is exceedingly complex, and has resulted in most remarkable phenomena. The rock-folds (and faults) are of all grades, from miles across down to microscopic. In some cases the original dividing plane (either bedding plane or fault plane) of two successive rock-sheets has been twisted into the form of spirals, cornucopias, etc. Folding, interfolding, buckling, shearing, stretching have all taken effect again and again along the junction (fault or bedding) plane between the Sedimentaries and Archæan; and innumerable protrusions of igneous rock—plutonic—have forced their way in numberless veins in the latter (Archæan) up to the former (Sedimentaries). At present, even near the line where the two distinct sets of rocks retain their recognizable individuality, the schistose layers that form the so-called lowest beds of the Eastern Schists are (occasionally) compounded of materials of such different origin that even in the same hand-specimen (from one locality) I believe that it can be sometimes demonstrated that certain parts of a layer may be mainly Assynt, other parts mainly Archæan, and other parts mainly intrusive or segregatory. The result is a comparatively homogeneous schist; but who shall indicate its geological age?

Schists composed of Archæan, Ordovician (sedimentary), and intrusive rocks respectively, form part and parcel of one and the same (lowest or heterogeneous) zone in the Eastern (Schistose) area, and intermingled with them occur schists (apparently) composed of mixtures of all three in different degrees. Here and there near the junction line (between the present Durness-Eriboll Series and the present Eastern Metamorphic Series) we can say: This band (*a*) is essentially or wholly Archæan; this (*b*) is certainly Ordovician; and this (*c*) probably intrusive rock. But as we go further east all recognizable distinctions vanish one by one, and in the present state of our knowledge all that we can presume to say is, that, considered as a whole, the Eastern Schist of Central Sutherland is in all probability an intimate compound of sheets of (1) Archæan, (2) Sedimentary, and (3) Intrusive rocks, which have been crushed into slaty rock, in which crystallization has set up along the cleavage planes.

The quartz, and possibly some of the mica, of the Upper Schists may have been largely derived from the Sedimentaries; hence the highly quartzose nature of these schists. Their felspar has either been derived from the Archæan, or from intrusive plutonic rocks.

So far as my own observations go, there seems to be no trace whatever of any sedimentary rock in the Durness-Eriboll region of more recent date than the Durness Limestone. The thin, so-called Upper Quartzite band of Sango Bay is the crushed basement zone of the Lower Quartzite. The green schists overlying it are pressure schists, formed and brought over in the great overfault. The same zone occurs again in Eriboll, along the great fault-line of the Upper Schist series. If (like those geologists who erroneously maintain that these Sango Bay Schists, etc., naturally succeed the Durness Limestone) we regard these green schists, etc., above the Limestone in the Sango Bay section as (forming part of) a true (sedimentary) sequence, we can prove with equally valuable evidence, indeed upon identical grounds—

(1) In Sango Bay that these green schists overlie the Limestone.

(2) In (near) Arnaboll that they follow at once to the basement bed of the Quartzite.

(3) In Eriboll (in some localities) that they are interstratified with the Hebridean.

(4) And (in other localities) that they trough the Lower Quartzite, coming out from below it.

(5) And also, as in Craig Faolinn, that they are the junction (transition) beds of the Lower and Upper Gneissic Series.

In other words, that they are below the Ordovician, above the Ordovician, in the Quartzite, above the Quartzite, in the Hebridean, and in the Upper Gneiss (so called) all at one and the same time!

I believe at present that the great area of metamorphic schists of Sutherland and the Central Highlands is, as a whole, neither Archæan nor Ordovician. The Sutherland Gneiss—Arnaboll—is Archæan. The Sutherland Schist has been manufactured[1] since Silurian times. For all I know, there may be large areas (in the Central Highlands, etc.) composed wholly of Archæan (Laurentian) rocks, or of Cambrian or pre-Cambrian rocks. When the metamorphism of the Highland area began I think that it is impossible to say, and may be always impossible. One thing seems pretty clear to me—the so-called oldest beds of the Highland succession of the Schistose Series of the N.W. Highlands are the newest in point of time. The zone of intermixture and metamorphism (in Sutherland) travelled to west from east, and the last beds (schists) manufactured are those now in contact with the Assynt Series in Durness, Eriboll, and Assynt.

Strikes, dips, and visible sequences are worse than useless in these metamorphic rocks as indices of chronological sequence. I cannot help believing that we have in the Highlands merely the remains of a degraded mountain complex. That fragment of the N.W. Highlands where the fossil-bearing beds occur, is the newest (of its component ranges) in point of time. Some ranges were certainly in existence in the Highlands in the Old Red times, and, for all we know to the contrary, some in Silurian times also. The Highland area has, I consider, been the theatre of mountain-making, and of igneous action again and again, since then. If the same crumpling has taken place over its whole surface as has certainly taken place in Eriboll, its present width must be the merest fraction of its original extent, and the manufacture of its schists and gneisses may have gone on in some localities below its surface from pre-Cambrian times to the present without interruption.

The attempt to claim all its (Central Highland) rocks as pre-Cambrian is perhaps a little more justifiable than the attempt to claim them as Silurian. At present the disproof of the "*visible ascending succession*" of the Murchisonian party is a brilliant triumph for the Nicolites. But the truth lies, I cannot help believing, between the two views. If I can prove my case, we shall find:—

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[1] (*i.e.* the heterogeneous materials of which it is composed have undergone re-arrangement, and have received a new and a common set of petrological features, through the agency of the great Earth-mill).

(1) That there is no recognizable chronological sequence (or invariable succession of superposition) in the metamorphic Highland area corresponding to that among the sedimentary formations (for the planes dividing the truly metamorphic layers are not planes of deposition, but planes of shearing and cleavage).

(2) Many of its (the Highland) schists are composed of Archæan materials (rocks), which have received their present pseudo-bedded arrangement since Ordovician times.

(3) What proportion of its schists and gneisses is composed of Archæan, sedimentary, or intrusive materials respectively is in all probability an insoluble question.

(4) Its *gneisses* may be either Archæan or (some) possibly formed by intrusion (injection of plutonic rocks) in later ages.

(5) Its *schists* may be composed either of crushed *Archæans*, crushed *intrusives*, or of a mixture of these with sedimentaries.

(6) Its (so-called) *slates* may be (according to the locality, either normal slates or) crushed rocks not yet crystallized (and) of either Archæan, sedimentary, intrusive, or of mixed origin.

II.—ON SOME QUARTZ-FELSITES AND AUGITE-GRANITES FROM THE CHEVIOT DISTRICT.

By J. J. HARRIS TEALL, M.A., F.G.S.

IN previous communications to the GEOLOGICAL MAGAZINE[1] I have described at some length the petrographical characters of the lavas and tuffs of the Cheviot District. It was proved that they are, at any rate for the most part, of an andesitic character, and that some of them are so little altered as to be thoroughly entitled to the term andesite, unless we are prepared to adopt the unphilosophical system of making geological age, *per se*, a factor in petrographical nomenclature. If we leave out of account the modifications in structure and composition which have been superinduced on the rocks by the various agents of change, then the Cheviot lavas and tuffs belong to the three fairly well characterized groups of the augite-, hypersthene-, and mica-andesites.

It is interesting to note that pumice and ash having essentially the same chemical and mineralogical composition as the Cheviot hypersthene-andesite was erupted in immense quantities by the volcano of Krakatoa in the autumn of last year: a fact which testifies in a striking manner to the uniformity in volcanic phenomena during immense periods of geological time.

In the present communication I propose to describe some intrusive rocks that occur in the Cheviot district. They belong to two well-marked groups—the quartz-felsites and the augite-biotite-granites.

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[1] Notes on the Cheviot Andesites and Porphyrites, GEOL. MAG. 1883, pp. 100, 145, 252.

It is necessary to state that my visit to the Cheviots was made fter the reading of a paper on the geological structure of the istrict at the Geological Society by Mr. Clough, at which I was resent. I was guided to many of the localities mentioned in this ommunication by information obtained from that paper. I regret ery much indeed that it has not yet been published. It deals with he mutual relations of the rocks referred to in the present communication, but so far as I can remember, it does not contain etailed petrographical descriptions.

THE QUARTZ-FELSITES.

I have observed these rocks in three localities in the porphyrite egion; in the Ridlees Burn about 1½ mile from its junction with he Coquet; in the Coquet itself about 1 mile above Shillmoor arm; and in the Usway rather more than ½ mile from its junction ith the Coquet. In each case the rocks occur as dykes in the orphyrites, and they are well exposed in the actual banks of the everal streams. There is no marked variation in the rocks from he different localities, and they may therefore be described collectively. In colour they vary from pale red to dull purple. In texture hey are not conspicuously porphyritic, the individual crystals rarely xceeding a length of two mm. Examined with a hand lens the most conspicuous mineral is seen to be biotite, which is evenly cattered through the rock in the form of beautiful hexagonal tablets. rystals of felspar, usually of the same colour as the ground-mass, ut occasionally weathering white, may be recognized. Grains of uartz are also seen to be present, but their importance as constituents f the rock is not recognized until the thin sections are examined. he matrix presents the usual felsitic character.

Under the microscope the biotite is seen to be of a perfectly normal haracter. Its boundaries are intact; a fact which shows that in the ase of this rock the magma exerted no corrosive action on the mineral. The only inclusions are apatite and magnetite. Quartz is he next mineral in importance. It usually occurs in irregular grains, ut occasionally in the form of more or less regular crystals. It ontains inlets and inclusions of the ground-mass, and sometimes the orm of the grain is as irregular as the island of Celebes. The elation of the quartz to the ground-mass is therefore seen to be hat which is so especially characteristic of the rhyolites. Mica occasionally occurs as an inclusion in the quartz. The felspars are so imilar in appearance to the ground-mass on account of the presence f irregular and ill-defined brownish flecks and scales (ferrite: Vogelsang) that they may sometimes be overlooked when examining he rock by ordinary light. Under polarized light they become at nce apparent, and in the majority of cases may be identified as rthoclase, a conclusion which is confirmed by Mr. Waller's analysis see p. 111). The ground-mass is perhaps the most interesting ortion of the rock so far as microscopic characters are concerned. t presents several very interesting modifications; but before proceeding to describe these, it seems advisable to make a few general remarks on the subject of the ground-mass of the quartz-porphyries[1] in order that the terms employed may be clearly understood.

The characters of this ground-mass have been made the subject of elaborate researches by many observers, and the most diverse opinions have been expressed as to their true significance. The whole subject has been discussed by Rosenbusch, with his usual critical ability, in his work "Die massige Gesteine,"[2] and in the following communication I propose to adopt his terms.

In any attempt to acquire definite ideas as to the nature of this ground-mass, it is advisable to remember that there are in this, as in every branch of petrography, two more or less independent points of view; the descriptive and the ætiological. We may consider the actual characters of the ground-mass without reference to their origin, or we may attempt to form some notion of the manner in which they have been produced. From the first point of view two modifications of the ground-mass stand out as the antitheses of each other, and present no difficulty in the way of description. On the one hand we have an isotropic glass, and on the other an aggregate which is capable of resolution, either with a hand lens or with the microscope, into a congeries of perfectly definite crystalline grains. The terms vitrophyre and granophyre were proposed by Vogelsang[3] to include those quartz-porphyries in which the ground-mass is present in one or other of these forms. Rosenbusch,[4] however, has shown that the granophyres of Vogelsang may be subdivided into two groups, to which he proposes to apply the terms micro-granite and granophyre. The rocks of these two groups are distinguished from each other by the mutual relations of the crystalline constituents of the ground-mass. In micro-granites these constituents are related to each other in the same way as the constituents of granite or granulite. They consist of crystalline grains, mostly of felspar and quartz, which are arranged without any regularity. In granophyres, on the other hand, the quartz and felspar are intergrown according to more or less definite laws, so that definite structures, such as micro-pegmatite, may be recognized in these rocks. One special type of structure which is frequently present in these rocks, and is often seen in association with the true micropegmatite, is termed by Rosenbusch pseudo-spherulitic. True spherulites, according to him, are composed of crystalline fibres of one and the same substance, all radiating from a common centre, and having an axis of elasticity parallel with the length of the fibre. They are therefore characterized under the microscope with crossed Nicols by a perfectly definite four-armed cross, the arms of which lie parallel with the vibration planes of the Nicols, and remain stationary as the stage is rotated. The spherulitic structures of the granophyres are, however, composed of quartz and felspar, so that the axes of elasticity in the different elements of the spherulite may have different positions in relation to the spherulite as a whole. Under crossed Nicols such a structure may give rise to more or fewer arms than the number characteristic of true spherulites, and these arms may not lie parallel to the vibration planes of the Nicols. Such structures, wherever they may occur, Professor Rosenbusch proposes to call pseudo-spherulites.

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[1] It must be remembered that the terms quartz-porphyry and quartz-felsite are not synonymous. The former term is the more comprehensive, as it includes such rocks as the porphyritic pitchstones (Vitrophyr of Vogelsang).

[2] Page 60.

[3] Die Krystalliten, Bonn, 1875, p. 160.

[4] Zusammensetzung und Structur granitischer Gesteine, Z.D.G.G. 1876, p. 369.

The granophyres, then, are distinguished by the presence of a micro-pegmatitic, pseudo-spherulitic or some allied structure in the ground-mass; whereas the ground-mass of the micro-granites is an irregular aggregate of crystalline grains. Rosenbusch also uses the adjective granophyric to express the various modifications of structure which occur in the ground-mass of the granophyres. It is somewhat unfortunate that the term granophyre should have been used in two senses, but no confusion will arise if we remember that the granophyre of Vogelsang comprises the micro-granite as well as the granophyre of Rosenbusch. It is always advisable in describing rocks and rock-structures to refer to typical examples. The rock from the summit of Carrock Fell, Cumberland, which was well described by Ward[1] as a spherulitic felsite, is a most beautiful granophyre, as that term is employed by Rosenbusch. The ground-mass sometimes shows the micro-pegmatitic structure only, and sometimes the pseudo-spherulitic; the two structures often co-exist and together they produce the granophyric structure of Rosenbusch. This rock is also interesting on account of the presence of well-formed crystals of a monoclinic pyroxene. It is identical with the granophyre[2] of the Fontaine Laquainte, Kirneckthal, Dep. des Vosges, which occurs as a dyke in the andalusit-hornfels of that district.

Between the micro-granites and granophyres on the one hand, and the vitrophyres on the other, we have a group of rocks (the felsophyres of Vogelsang) about which the most diverse opinions have been held. It is with reference to these that the terms micro-felsite and crypto-crystalline have been used. They can be defined only by employing negative characters. Their ground-mass is neither a true glass nor a recognizable aggregate of crystalline grains. When examined under polarized light, it may or may not appear perfectly isotropic. If isotropic, it is distinguished from a glass by the fact that it appears to be composed of ill-defined flecks, scales, fibres, and granules. To this Rosenbusch proposes to restrict the term micro-felsite, and there is no doubt that if this proposition be generally accepted, it will tend to facilitate very greatly the precise description of rocks of this class. If not isotropic, then it is distinguished from the micro-crystalline ground-mass by the apparent absence of definite boundaries to the doubly refracting particles. The term crypto-crystalline is applied to this structure.

Now in dealing with this crypto-crystalline ground-mass, we experience precisely the same difficulties as those experienced by the older petrographers in dealing with the felsitic base. The introduction of the microscope has not removed the difficulties; it has only pushed them a little further back. Let us endeavour to take stock of our present position in relation to this subject.

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[1] Q. J. G. S. vol. xxxii. p. 20.

[2] Die Steiger Schiefer, p. 345.

In discussing the question it is necessary to remember that the microscope does not enable us to approach the limits of the molecular world. There is room for a universe of phenomena, so to speak, between the limit of microscopic visibility and that of molecular structure. Hence, many structures and modes of association in minerals which we observe macroscopically and microscopically, as well as others which we cannot observe, may exist in this ultra-microscopic universe. Now many rocks which show a crypto-crystalline structure, when examined in thick sections and with low powers, may be resolved, by reducing the thickness of the sections and by using higher powers, either into a micro-crystalline aggregate or into doubly refracting particles, and a glassy or micro-felsitic base. If the doubly refracting particles are small in comparison with the thickness of the slide, then, owing to their superposition, they will give rise to the indefinite aspect under crossed Nicols which is the special characteristic of crypto-crystalline matter.

These considerations lead us, therefore, to the conclusion that the term crypto-crystalline includes different things and is useful merely for the purpose of expressing our ignorance as to the precise condition of the matter to which it is applied. It is an expression which is rendered necessary in consequence of imperfection in our methods of observation, and does not correspond with anything definite in the nature of things. It is a subjective and not an objective term, and one that we must therefore use for the purpose of expressing our ignorance, and not for the purpose of concealing it. In concluding this discussion it is well to remark that the felsophyres, granophyres, and micro-granites cannot be distinguished from each other by macroscopic examination. All that we can do in the field is to separate the quartz-porphyries with a vitreous from those with a felsitic ground-mass. The former may be termed vitrophyres, while for the latter our own term, quartz-felsite, is very appropriate.

If we consider the porphyry ground-mass from the ætiological point of view, then we have to recognize the fact that the micro- and crypto-crystalline ground-masses may owe their double refraction either to crystallization at the time of consolidation or to the subsequent devitrification of an original glassy substance. Perlitic structure, so far as we know, can only arise during the consolidation of a glass, and we may therefore fairly conclude with Mr. Allport[1] and others that rocks which show this structure were originally in the glassy condition. In many cases, however, a perlitic rock will split up under crossed Nicols into a micro-crystalline aggregate. So far as I know, we have at present, in the absence of perlitic or some other structure equally characteristic of a glass, no test by which we can distinguish an original micro- or crypto-crystalline ground-mass from one which has been produced by subsequent devitrification. Here again we have to make a confession of ignorance.

If we look at the quartz-porphyries in their relations to other

[1] On Devitrified Pitchstones and Perlites of Shropshire, Q.J.G.S. vol. xxxiii. p. 449.

rocks, we see that they shade off on the one side into rhyolites, and on the other into granites. As a whole, they occupy the same position in the acid series as the diabases and dolerites in the basic series; they are intermediate between the volcanic and the plutonic rocks, but without well-defined limits.

The subdivisions as well as the general relations of the quartz-porphyries may be expressed as follows:

Volcanic.	RHYOLITE.		
Intermediate.	QUARTZ-PORPHYRY	Vitrophyre	
		Quartz-felsite	Felsophyre. Granophyre. Micro-granite.
Plutonic.	CERTAIN GRANITES.		

I now proceed to give a description of the ground-mass of the Cheviot quartz-felsites. Examined by ordinary light it never presents the appearance of a true glass. Ill-defined specks, flecks, fibres, and scales of a brownish substance (ferrite), are everywhere present and lie superposed over each other in the thinnest sections. As a rule these are scattered uniformly throughout the substance of the ground-mass, but in some instances they give rise to small spherical aggregates exactly as in certain rhyolites from Hungary and the Ponza Islands. Under crossed Nicols the ground-mass is seen to be micro- or crypto-crystalline; no portion appears to remain dark under crossed Nicols. In one case a very interesting structure occurs. The ground-mass presents a perfectly normal appearance when examined by ordinary light, but under crossed Nicols it splits up into a coarse-grained crystalline aggregate. The boundaries of the different doubly-refracting grains are perfectly irregular, and are not recognizable by ordinary light. Every quartz crystal in the rock forms the nucleus of one of these grains, so that the space surrounding it extinguishes simultaneously with the crystal itself. This fact seems to show that the substance which has determined the definite optical characters of the ground-mass is quartz, although other substances must be present in considerable quantity. I incline to the view that we have here a case of true devitrification; but as there are no structures especially characteristic of glass, it seems impossible to be certain on this point.

In some slides the pseudo-spherulitic structure may be detected in places, and this may be taken as indicating an approach to the granophyric structure of Rosenbusch.

Mr. Waller kindly analyzed a specimen from a point in the Coquet about ½ mile above Shillmoor Farm, with the following result:

SiO_2	67·9
Al_2O_3	15·7
Fe_2O_3	3·0
CaO	1·4
MgO	1·5
Na_2O	1·5
K_2O	5·6
Loss	3·7
	100·3

In addition to the quartz-felsites above described, there are others in the granitic region; but as these, at any rate in places, appear to me to be of the nature of contemporaneous veins, I will refer to such as I have observed in describing the granitic rocks.

THE AUGITE-BIOTITE-GRANITE.

It has long been known that in the sparsely populated but by no means inhospitable recesses of the Cheviot Hills extensive tracts of granitic rocks occur. The precise relations of these rocks to the porphyrites have not yet been described, and we must wait until the Survey Maps and publications are out before we can obtain detailed information on this subject. My own knowledge of these rocks, as they occur in the field, was obtained during two short excursions; one to Linhope Spout, the other involving a walk from Usway Ford round the head-waters of the Breamish, by Staindrop Rigg and Hedgehope, to Langley Ford in the valley of the Harthope Burn. As it was necessary to get from Usway Ford to Wooler in one day, there was no time available for a search for junctions, and I had to content myself with collecting specimens of such rocks as came in my way.

The principal interest attaching to these rocks centres in the fact that they present us with a type hitherto unknown in Britain, and by no means widely recognized in other parts of the world. They are true augite-bearing granites similar in all essential respects to the augite-granite of Laveline in the Vosges, described by Rosenbusch,[1] and that of Oberbruck also in the Vosges, described by Cohen.[2] Prof. Rosenbusch has seen my specimens, and agrees with me in my determination; he has also very kindly supplied me with specimens of the rocks from Laveline and Oberbruck.

As the augite is the most interesting constituent, I will describe it before proceeding to refer to the rocks in which it occurs. It is present in the form of irregular grains, granular aggregates, and sometimes, though rarely, in more or less definite crystals. It is almost colourless in thin section, exhibiting only a slight inclination to a pale green tint. Inclusions of magnetite are not uncommon. Cross sections show the characteristic cleavages of augite, and longitudinal sections give a maximum extinction of 43° or 44°. Twinning may occasionally be observed. Alteration tends to develope serpentinous and not chloritic products, and the separation of iron-oxide appears to accompany the change. In appearance the mineral is identical with the augite of the Vosges rocks above referred to, and we may safely conclude that it has an analogous composition.

Dr. Alphonse Merian[3] has recently isolated and analyzed the augite of the Laveline rock, and he finds that it possesses the following composition:—

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[1] Z. D. G. G. 1876, p. 369.

[2] Neues Jahr. 1883, vol. i. p. 200.

[3] Studien an gesteinsbildenden Pyroxenen. Neues Jahrbuch III. Beilage Band, p. 262.

SiO_2	50·63 %
Al_2O_3	·87
Fe_1O_3	3·33
FeO	8·39
MgO	13.01
CaO	21·30
Na_2O	1·02
K_2O	·50
TiO_2	·79
	99·84

Sp. Gr. 3·372.

It is therefore a non-aluminous iron-bearing augite of the diopside type allied to the augite of the augite-syenites. The tendency of the mineral to pass into serpentinous rather than chloritic alteration products is of course due to the absence of alumina.

I now proceed to describe the rocks in which the above mineral occurs. They are usually coarse-grained, holocrystalline, non-porphyritic rocks, which vary considerably in aspect and in the relative proportions of the different constituents. Some of the varieties are dark and syenitic-looking; others resemble a grey or pink granite of normal aspect. Owing to the variability of the rocks, it will be advisable to describe the special types which have been examined.

Linhope Burn, ⅓ mile above Linhope Farm.—A dark-coloured syenitic-looking variety, composed of orthoclase, plagioclase. with low extinction angles, quartz, augite, biotite, magnetite, apatite and serpentinous alteration products. Felspars of both kinds very abundant. Augite well represented. Quartz in moderate quantity.

Linhope Spout.—In the immediate neighbourhood of the waterfall several very interesting rocks may be observed. The augite-granite is here traversed by dykes and veins of quartz-felsite, which sometimes show under the microscope the micro-granitic, at other times the granophyric structures. These two structures often co-exist in the same slide, but as a rule one or other predominates. Biotite and augite are occasionally present, but the latter mineral is decidedly rare. I incline to the view that these are of the nature of contemporaneous veins, and if so, a very interesting conclusion, which will be referred to later on, may be drawn from this fact. They are evidently more acid in composition than the normal rock. The augite-granite of Linhope Spout is a coarse-grained rock. in which flesh-coloured orthoclase, light-coloured plagioclase, biotite and a dark green mineral (the augite) may be recognized by macroscopic examination. Under the microscope quartz is seen to occur abundantly, the augite may be identified, and magnetite and apatite may be recognized. One very interesting feature is the tendency of the quartz and felspar to form micro-pegmatite. This is also noticeable in the augite-granites of the Vosges, and it may therefore be regarded as a characteristic feature of this class of rocks.

Staindrop Rigg.—On the high ground between the Het Burn and Staindrop Burn there are two conspicuous craggy bosses of a greyish granite. These form Staindrop Rigg. A similar rock occurs low down to the S.E. of this exposure, so that in all probability it forms an extensive tract in this district. Examination with a hand lens enables one to recognize easily a pink potash felspar, a light-coloured almost white plagioclase, biotite and quartz. The felspars sometimes measure ¼ of an inch across, and so give the rock a slight porphyritic aspect. They may be easily isolated and examined by Szabo's method. I give below the results of my own examination of these felspars and also those obtained by myself and Dr. Szabo on some typical felspars.

EXAMINATION OF FELSPARS BY SZABO'S METHOD.

	1st Experiment.			2nd Experiment.			3rd Experiment.	
	Na_2O 1—5	K_2O 1—3	Fusibility. 1—4	Na_2O 1—5	K_2O 1—3	Fusibility. 1—5	Na_2O 1—5	K_2O 1—4
A (T)	4—5	0	3—4	4—5	0	4—5	5	1—2
B (S)	4—5	0	3—4	4—5	0	4—5	4—5	1—2
C (S)	3—4	0	2—4	3—4	0	3—5	3—4	1—2
D (T)	3	0	2—3	4	0	4	4—5	1
E (T)	4	0	2—3	4—5	0	4	5	1
F (T)	3	2	2—3	3	2—3	4	4	3
G (S)	3—4	2	2	3—4	2	4	3—4	3

A. Oligoclase Twedstrand (Teall).
B. Oligoclase (Szabo).
C. Andesine (Szabo).
D. Andesine, Scourie Dyke (Teall).
E. Plagioclase, granite, Staindrop Rigg (Teall).
F. Orthoclase, granite, Staindrop Rigg (Teall).
G. Perthite group (Szabo).

Mr. Waller, of Birmingham, appears to have been the first observer who applied Szabo's method to the practical determination of minerals in this country, and I am indebted to that gentleman for instruction in the working of the method. There is no doubt that it is a quick and reliable method for obtaining very valuable information as to the nature of the constituents of rocks. The above experiments prove clearly that the plagioclase belongs to the oligoclase-andesine group and the potash felspar to the perthite group of Szabo; a group which is characterized by the presence of from 4 to 6 per cent. of soda.[1]

The two felspars occur in about equal proportions in the rock from Staindrop Rigg. Augite and magnetite may be recognized under the microscope, but they are far less abundant than in the syenitic-looking varieties from Linhope Spout. Quartz on the other hand is more abundant. The microstructure of the rock is thoroughly granitic. Narrow contemporaneous veins of quartz and felspar with very little biotite may be observed in the mass of the rock at Staindrop Rigg.

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[1] In is interesting to note that the augite-syenites and their porphyritic equivalents of the Christiania district contain felspar rich in soda which appears to be sometimes monoclinic and sometimes triclinic, with a cleavage angle differing but slightly from 90°. Brögger has described these two forms in great detail (Die Silurischen Etagen 2 und 3, p. 203, et seq.). He names them soda-orthoclase and soda-microcline.

Comb Fell.—I collected several specimens from the western side of Comb Fell. They are all varieties of a pinkish biotite granite, in which orthoclase appears to be the dominant felspar. Augite is present only in very small quantity.

Hedgehope.—This mountain is largely if not entirely composed of granite. Specimens from the eastern side are similar in character to those from Staindrop and therefore require no special description.

In taking a general view of the holocrystalline granitic rocks of the Cheviot District one fact stands out in a prominent manner. They are by no means uniform in composition. Some are rich in basic minerals, others are comparatively poor; some contain plagioclase, others a soda-orthoclase, as the dominating felspar. The different varieties do not appear to be in all cases sharply separated from each other. A possible explanation of this variability will be referred to later on.

COMPARISON OF THE CHEVIOT AUGITE-GRANITES WITH ALLIED ROCKS OF OTHER DISTRICTS.

The occurrence of augite rocks containing quartz and orthoclase is such a striking violation of one of Breithaupt's laws of paragenesis as to give these Cheviot granites a special interest.

This occurrence was first recognized according to Rosenbusch[1] by Vom Rath in the case of a quartz-porphyry from Campiglia (Tuscany), which contains orthoclase, plagioclase, augite, magnetite, mica, and quartz. In North Saxony, near Leipzig, there is an extensive development of augite-bearing quartz-porphyries. These rocks have been investigated by Tschermak, Naumann, Kalkowsky, Rosenbusch, and Penck. They are classed with the upper portion of the middle Rothliegende by the last-mentioned author.[2] Rosenbusch[3] has identified a rhombic as well as a monoclinic pyroxene in these rocks, and I may mention that in one case I observed in a Cheviot granite a mineral that was most probably enstatite or bronzite.

Then again there are the remarkable pyroxene-granulites of the granulitic region of Tuscany which have been described by Stelzner,[4] Dathe,[5] and Lehmann.[6] These have been divided by Dathe into orthoclase- and plagioclase-diallage-granulites, according to the nature of the dominant felspar. They contain monoclinic and rhombic pyroxenes, and in this respect resemble the quartz-porphyries of North Saxony. Until recently they have always been regarded as Archæan, but the work of Dr. Lehmann has destroyed much of the evidence on which this conclusion was based.

In the same connexion we must mention the quartz-less augite-syenites of Monzoni, described by Vom Rath,[7] and those of Norway described by many observers, but especially by Br gger.[1] The orthoclase in these rocks, like that of the Cheviot granites, is rich in soda. The augite-granites of the Vosges have been already referred to, and as they are very closely related to the Cheviot rocks, it is necessary to quote their analyses.

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[1] Massige Gesteine, p. 58.

[2] Die pyroxen-führenden Gesteine des nord-sächsichen Porphyrgebietes, Min. Mitth. 1881, p. 72.

[3] Massige Gesteine, p. 58.

[4] Neues Jahr. 1871, p. 246.

[5] Z. D. G. G. 1877, p. 285.

[6] Die Entstehung der alt-krystallinischen Schiefer-gesteine, p. 228.

[7] Z. D. G. G. 1875, 343-357.

	I.	II.
SiO_2	61·93	62·09
TiO_2	—	·56
Al_2O_3	13·18	16·43
Fe_2O_3	3·63	2·34
FeO	2·31	2·03
CaO	3·48	2·32
MgO	4·59	3·08
Na_2O	2·67	4·07
K_2O	6·11	4·66
H_2O	1·14	·85
	99·04	98·43

I.[2] Augite-Granite from Laveline. Sp. Gr. 2·723.
II.[3] Augite-granite from Oberbruck. Analyses by Werveke.

Rosenbusch[4] has also recognized fresh pyroxene in the Vosges, porphyries of Etival, Rothau, Rochesson, and in a rock which is sometimes a quartz-porphyry and sometimes a granite from the Titisee in the Schwartzwald. He remarks that the mineral is absent as a rule from massive granites, but that he has observed it abundantly in one case, viz. that of a rock from the Julier Pass.

MUTUAL RELATIONS OF THE IGNEOUS ROCKS OF THE CHEVIOT DISTRICT.

The facts, so far as they are known at present, appear to show that the first period of volcanic activity in this district was marked by the eruption of immense quantities of andesitic lava and tuff.

The andesites fall into three groups, characterized respectively by the minerals hypersthene (bronzite), augite, and mica. Most of them are now much altered, and to these altered forms I have restricted the term porphyrite. The presence of tuffs, vesicular and amygdaloidal varieties of lava, and actual evidences of flow, proves that the conditions of eruption were substantially identical with those of modern times.

The eruption of andesitic material was followed by the intrusion of quartz-felsite dykes. If the magma which produced these dykes ever reached the surface, it must unquestionably have formed rhyolites and rhyolitic tuffs. Do such rocks occur anywhere in the Cheviot District? The dykes of quartz-felsite occur in the porphyrite region, so that we have conclusive evidence to show that the eruption of acid followed that of andesitic material in the history of the Cheviot Old Red Sandstone volcanoes.

The intrusion of quartz-felsite dykes appears to have been the concluding phase of the volcanic activity of Old Red Sandstone times; for such dykes as those of Acklinton, which cut the Carboniferous rocks of North Northumberland as well as the igneous rocks of the Cheviot district, and are intermediate in composition between basalts and andesites, may be referred with a considerable amount of confidence to the Tertiary period.

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[1] Die silurischen Etagen 2 und 3.
[2] Studien an gesteinsbildenden Pyroxenen, Merian.
[3] Neues Jahr. 1883. I. 201.
[4] Z.D.G.G. 1876, p. 369.

In the present communication it has been shown that the district about Hedgehope, Comb Fell, Staindrop and Linhope Spout is occupied by holocrystalline, non-porphyritic rocks of the plutonic type. Are these rocks due to the consolidation, beneath the surface, of the magma which produced the andesitic lavas and tuffs? Do they occupy the same position in relation to the Cheviot lavas as the gabbros and granites of Mull do to the lavas of Mull according to Prof. Judd? The evidence available is not so complete as we could wish, but, such as it is, it points decidedly to an affirmative answer to the above questions.

The augite-granites are evidently not characterized by a high percentage of silica. Some of them strongly resemble syenites in appearance; but as quartz is present in all my specimens, the term syenite cannot be applied to any of them. True augite-syenites may of course occur in the district, as my observations were necessarily of a very limited character. The analyses of the Vosges augite-granites show that these rocks belong to the intermediate, rather than to the acid class; and that the bases, if we except the alkalies, are present in approximately the same relative proportions as in the Cheviot lavas. With regard to the alkalies, I would remark that we have no analyses of the Cheviot plutonic rocks; but it is certain that the orthoclase is rich in soda, and that plagioclase of the oligoclase-andesine type is sometimes present in greater quantity than the orthoclase. I have little doubt that in some of the plutonic rocks the relative proportions of the two alkalies is the same as in the normal andesites. Again, Mr. Waller's analysis of a porphyrite from Shillmoor[1] shows an excess of potash over soda.

There is another point in connexion with the volcanic history of the Cheviot district in Old Red Sandstone times which seems worthy of special attention. Why did the quartz-felsites succeed the andesites?

One of the most fascinating problems of geology is to account for the variation in the composition of the material erupted at different periods in the volcanic history of a district. Now in considering the possible causes of this variation careful attention should be paid to the changes brought about in the composition of a magma by the successive crystallization of different constituents.

Information on this subject may be obtained in at least three different ways: (1) by observing the order in which minerals have crystallized in different magmas; (2) by examining the chemical and mineralogical composition of the ground-masses of porphyritic rocks; (3) by examining the so-called contemporaneous veins which are especially characteristic of plutonic rocks.

Prof. Rosenbusch[2] and others have shown that as a general rule the minerals separate out in the order of their basicity; the more basic minerals, or those which do not contain silica, being the first to form. This being admitted, we see at once that the tendency of the progressive crystallization must be to render the magma more and more acid.

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[1] Geol. Mag. Dec. II. Vol. X. p. 151.

[2] Neues Jahr. 1882, ii. p. 1.

Dr. Petersen has isolated and analyzed the glassy base of the Cheviot hypersthene-andesite and the devitrified base of a porphyrite from Allerhope Burn. His analyses appear to me to have such an important bearing on the sequence of volcanic phenomena in the Cheviot district that I quote them below, together with two analyses of the Cheviot lavas.

They show that the ground-mass is richer in silica and alkalies, and that the ratio of potash to soda is much greater in the ground-mass than in the rock as a whole.

	I.	II.	III.	IV.
SiO_2 ...	66·25	65·16	61·17	59·05
Al_2O_3 ...	13·59	17·49	16·87	15·69
Fe_2O_3 ...	3·11	3·01	2·10	1·80
FeO ...	—	—	2·94	4·72
CaO ...	2·75	0·84	4·86	1·79
MgO ...	·28	2·34	3·00	4·29
K_2O ...	4·95	5·54	1·81	2·88
Na_2O ...	2·25	3·68	2·67	3·97
H_2O ...	5·89	1·76	3·09	3·16
	99·07	99·82	98·51	97·35
Sp.Gr.	2·437	2·640	2·543	

I. Glassy base. Hypersthene-andesite.
II. Devitrified base. Porphyrite. Allerhope Burn.
III. Hypersthene-andesite. Carhope on Coquet.
IV. Porphyrite, ¼ mile above Shillmoor Farm.

Mr. Stock[1] has shown that the ground-mass of the Cockfield dyke is also richer in silica than the normal rock. Mr. Waller, of Birmingham, has recently investigated certain contemporaneous veins in the bronzite-diabase of Penmaenmawr. He finds that they contain 6¼ per cent.[2] more silica than the rock in which they occur, and that potash is present in excess of soda, whereas the reverse relation holds in the rock itself. These veins then bear precisely the same relation to the parent rock as the ground-mass of the Cheviot andesite does to the mass of the andesite.

There are veins in the Rowley Rag basalt, also described by Mr. Waller, which contain 9 per cent. more silica than the rock, and possess as much as 11 per cent. of alkalies.

From these and other facts which need not be here enumerated, we may safely draw the general conclusion that the effect of progressive crystallization is to increase the percentage of silica and alkalies, to increase the potash relatively to the soda, and to diminish the lime, iron, and magnesia in the liquid magma. Rocks of rhyolitic composition may represent, so to speak, the mother-liquor out of which the basic minerals have crystallized.

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[1] North of England Dykes, Q.J.G.S. 1884, p. 225.

[2] Midland Naturalist, 1885, p. 6. Compare the concretionary (?) patches (*e.g.* certain inclusions in granite described by Mr. Phillips, Q.J.G.S., vol. xxxvi. p. 1, and the nodules of peridotite in basalt) with the so-called contemporaneous veins. The former are as a rule more basic, the latter more acid than the normal rock. The former may represent the earliest, the latter certainly represent in many cases the latest products of consolidation of an originally homogeneous magma.

Suppose, now, that the crystallization occurs under conditions which admit of the mechanical separation by gravity of the crystals and the magma in which they are formed. This would give rise to some very interesting results.[1]

Consider the case of an internal reservoir of molten-rock, and for the sake of simplicity, suppose the conditions of crystallization to be realized in the upper portion. The basic minerals will form and then fall by reason of their high specific gravity.[2] On descending to lower levels, they may be dissolved, and thus a variation in the composition of the originally homogeneous magma may be produced. Diffusion will tend to restore homogeneity; but the above cause, operating in the contrary direction, may be the more potent of the two, and if so, a permanent difference in composition will be established. When final consolidation occurs, a mass will be produced which will vary in composition from top to bottom; the most acid portion occurring in the former, the most basic in the latter position. In the Cheviot district the augite granites vary considerably in composition and different varieties sometimes appear to shade into each other. The same feature may be observed in rocks which I cannot but regard as igneous, in the Carrock Fell region in Cumberland. The highly basic gabbros of Mosedale Crags appear to shade into the acid granophyres of the summit of the hill. Is it possible that these facts may be due to an action of the kind above referred to?

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[1] Separation may be effected without gravity. Suppose a half-consolidated plutonic mass to become subject to the lateral thrust of which there is such striking evidence in certain districts. The mother-liquor may be squeezed out of the rock as water out of a sponge. In this way contemporaneous veins might be produced in the plutonic rock, dykes in the surrounding rock, and lavas at the surface.

[2] The subject of the separation of crystals in a molten magma has been discussed by many writers. It is important to notice that it must occur if there be any difference between the specific gravity of the crystals and that of the magma in which they exist. The only question that can arise is as to the geological significance of the operation. Mr. Darwin deals with the subject in his Geological Observations (2nd edition, p. 132), where he describes certain phenomena in the Galapagos Islands which he attributes to this cause. He also quotes a statement from Von Buch that M. Drée found, on melting lava, that the felspars always tended to fall to the bottom of the crucible. The Pattison process for separating lead from silver is mentioned by Mr. Darwin, and it certainly has a very interesting bearing on the subject under consideration.

Again, Mr. Clarence King (Systematic Geology, p. 678) says: "During an eruption in the crater of Kilauea at the time of my visit, a fluid stream of basalt overflowed from the molten lake at the west end of the crater and poured eastward along the level floor of the pit. Numerous little branchlets spurted out from the sides of the flow and ran along the depressions of the basaltic floor, for a few feet and then congealed. I repeatedly broke these small branch streams and examined their section. In every case the bottom of the flow was thickly crowded with triclinic felspars and augites, while the whole upper part of the stream was of nearly pure isotropic and acid glass." The sinking of felspars in a basaltic magma strikes one at first sight as an impossibility; but the observations of Darwin and King and the experiments of M. Drée appear to prove the fact in a conclusive manner. We must infer, therefore, that the specific gravity of the molten magma is less than that of the felspars.

The point, however, to which I wish to direct special attention is this. The eruption of andesitic lavas and tuffs in the Cheviot district was followed by the intrusion of quartz-felsite dykes. The plutonic rocks of this district are traversed by veins of quartz-felsite. If these veins be of the nature of contemporaneous veins, as I believe them to be, at any rate in part, then they owe their special chemical characters to progressive crystallization in a magma of andesitic composition, and we may see in this a reason why quartz-felsites succeeded andesites in the history of the Cheviot volcanoes. This view receives strong confirmation from the fact that the ground-mass of the andesitic lavas is substantially identical in composition with the quartz-felsites; as will be seen at once by comparing the two analyses by Dr. Petersen with the analysis of the quartz-felsite by Mr. Waller, which is given in the earlier part of this paper.

If we compare the history of volcanic action in the Cheviots with that of other districts, we are struck by many points of resemblance. The succession, andesite, trachyte, rhyolite, is common to many volcanic regions, including Hungary, the Lipari Islands, and North America.[1]

The sequence of volcanic rocks is, however, usually complicated by the introduction of basalt during the later phases of volcanic activity, a fact which shows that the view adopted for the purpose of explaining the volcanic sequence in the Cheviot district is not in itself sufficient to cover all cases. Doubtless, as Captain Dutton has pointed out, many factors are involved in the determination of the sequence.

The phenomena of the Lipari Islands, so admirably described by Prof. Judd,[2] furnish a very interesting case. The first period of activity in this region appears to have been characterized by the eruption of andesitic material. Then, as time went on, the products diverged, as far as composition is concerned, in opposite directions, and in modern times we see Stromboli erupting basic and Vulcano acid material. The sequence can be explained if we regard the products of Vulcano as formed from the mother-liquor and those of Stromboli as resulting from the refusion of the basic minerals which have separated out of it.

There is one interesting point, almost of the nature of a paradox, to which attention has frequently been directed, but which it seems advisable to refer to in connexion with the present subject. The fusion point of basic rocks is lower than that of acid rocks. and yet minerals separate out as a general rule in the order of their basicity, the more basic being the first to form. How is this to be explained?

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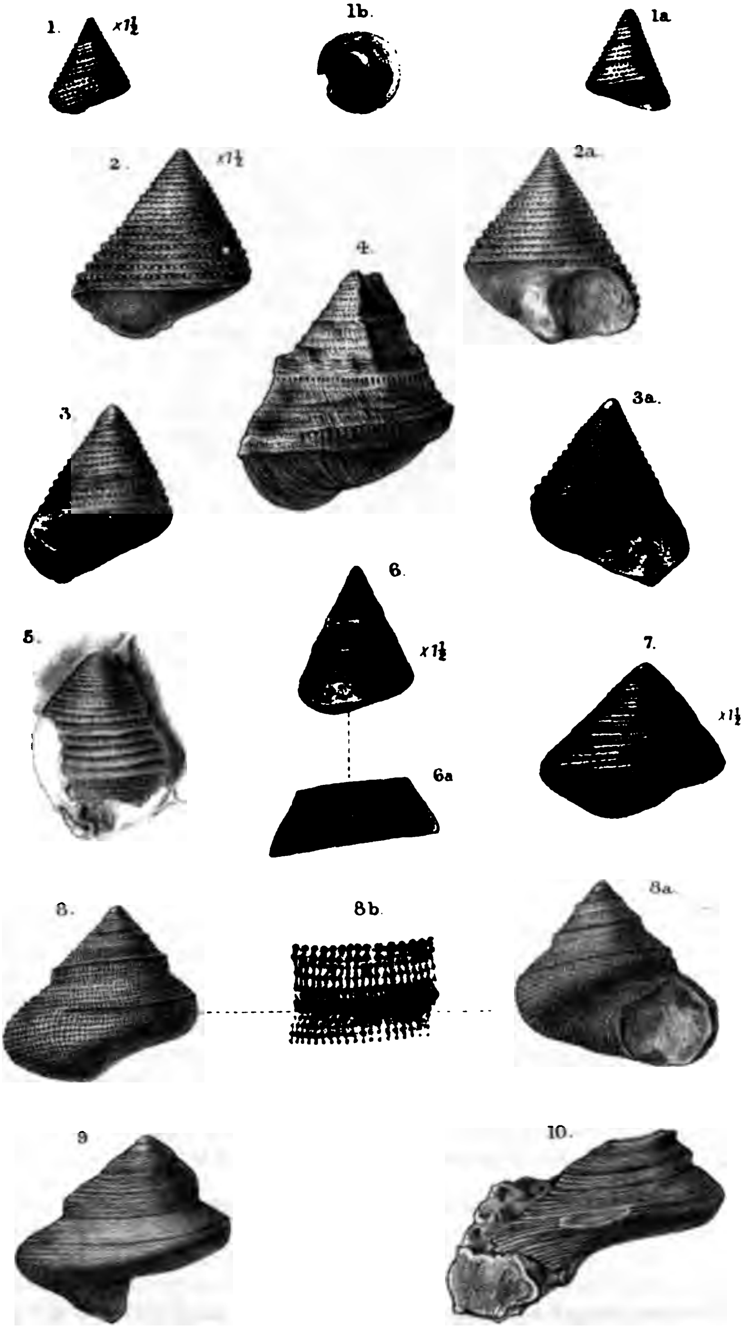
[1] Propylite, the rock which has long been supposed to mark the first period of volcanic action in Tertiary times, has been shown by the recent work of Dr. Becker (Geology of the Comstock Lode) to comprise, in America, altered forms of well-known rocks, especially andesite, and a similar conclusion had been previously arrived at by Dr. Wadsworth.

[2] GEOL. MAG. 1875.



A. S. Foord del. et lith. Mintern Bros. i

Oxfordian and Lower Oolite Gasteropoda; Yorkshire.

A complete and satisfactory answer to this question remains to be discovered; but there are one or two facts of great significance which bear upon it. In the first place, we notice that there is no connexion between the temperature at which a mineral separates from a magma in which its constituents are held in solution, and its own fusibility further than this—that no mineral can form at a higher temperature than its own fusing point. Graphite, one of the most infusible substances, crystallizes out of molten iron. Quartz must constantly form at a point far below that of its own fusibility. Then, again, there is the great question, first brought into prominence by Scrope, as to the influence of water in determining the liquidity of lavas. Dr. Petersen has shown that the glassy base of the Cheviot hypersthene-andesite is rich in water; the devitrified base, on the other hand, is poor in water.

The whole subject discussed in the last part of this paper is one of great interest; but we must be content to wait for a further accumulation of facts before a perfectly definite judgment can be formed. To those who collect and arrange these facts so as to remove the subject from the region of controversy will belong the chief merit of discovery.

III.—CONTRIBUTIONS TO THE PALÆONTOLOGY OF THE YORKSHIRE OOLITES.

By WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S.

(Continued from Decade III. Vol. II. p. 59.)

(PLATE III.)

74.—TROCHUS MONILITECTUS, Phillips, 1829. Plate III. Figs. 1, 1*a*, 1*b*.

1829 and 1835. *Trochus monilitectus*, Bean; Phillips, G Y., p. 123 (p. 165 as *T. moniliferus*, P.), pl. ix. fig. 33.
1849. *T. monilitectus*, Phil.; D'Orbigny,, Prod. p. 265. Ét. Bajoc.
1854. *Ibid.* Phil.; Morr. Cat., p. 281.
1875. *Ibid.* Bean; Phillips, G.Y., 3rd ed. p. 259, pl. ix. fig. 33.

Bibliography, etc.—This somewhat insignificant fossil approaches several of the small granulated or tuberculated species of *Trochus* (or *Monodonta*), which are distinguished by a completely conical outline, resulting from a close suture and perfect flatness of the whorls. Although without description, Phillips's figure is characteristic, and it is somewhat singular that this species was not recognized by D'Orbigny amongst the fossils of the French Jurassic. The typical form is confined, in Yorkshire, so far as I know, to the Scarborough Limestone (zone 3), where it is rare, and, for the most part, so imperfectly preserved, that accurate description is a matter of some difficulty.

A single specimen referred to *T. monilitectus* from the Cornbrash of Scarborough is in the Leckenby Collection. It presents certain differences of ornamentation, and will be described as var. B. To recognize a distinct species founded on a single specimen would be imprudent, when the differences are not great. Should more specimens of var. B. be found, either in Yorkshire or elsewhere, the case would be altered. Phillips's type may be examined in the York Museum.

Descriptions.—The USUAL FORM. Specimen from the Scarborough Limestone (zone 3), Cloughton (?), Bean Collection, British Museum. Figs, 1, 1*a*, 1*b*.

Height	8 millimètres.
Width	7·5 ,,
Spiral angle	60°.
Ratio of body-whorl to entire shell	36 : 100.

Shell small, conical, imperforate. The spire increases under a very regular angle, and is nearly equilateral. Whorls perfectly flat, suture extremely close (so close that it is not easy to count the number of whorls). The ornaments consist of five (?) equal spiral bands which are rather close together and evenly tuberculated, the tubercles or granules being nearly circular, or at least only slightly drawn out spirally; the body-whorl possesses four of these tuberculated spirals, together with a thicker belt constituting the basal periphery.

Base nearly flat, outer area spirally striated; columellar area nearly smooth, or only marked with faint radial lines. Aperture rhomboidal and depressed, with a very short columella, which possesses indications which might be interpreted as representing a tooth.

VARIETY B.—Specimen from the Cornbrash (zone 4), Scarborough. Leckenby Collection. Not figured.

In size and proportions almost identical with the last; it corresponds also with specimens from the Scarborough Limestone in the perfectly conical outline, and in the closeness and comparatively large tuberculations of the spirals. The differences are, that the uppermost spiral is bi-tuberculate and constitutes a very slight prominence or zone: on the other hand, the basal belt of the body-whorl is sharper and less broad than in specimens from the lower horizon.

Relations and Distribution.—This species must be regarded as the representative of the small, conical, granulated or tuberculated Trochids, which occur throughout the Lower Oolites more or less sparingly. Turning to the Paléontologie Française, we find such species as *T. Brutus* (T. J. p. 283, pl. 315, figs. 13–16), *T. Luciensis* (p. 288, pl. 317, figs. 5–8), and *T. Zenobius* (p. 289, pl. 317, figs. 9–12), all more or less near to *T. monilitectus*. *T. Zenobius* is very near indeed, but is represented as having four spirals. *Trochus eutrochus*, Laube (Gaster. von Balin, p. 10, pl. 2, fig. 5), also belongs to this group: it is stated by that author to occur in the Great Oolite of Bayeux, and rarely in the Brown Jura of Balin. It would be unsafe to say how nearly these forms are identical with Phillips's species.

T. monilitectus, or a very similar form, occurs in the Lincolnshire Limestone, and also in some of the shell beds of the Inferior Oolite of the Cotteswolds. But there are certain differences of ornamentation, and specimens from the same bed exhibit, some four, some five spirals: hence it is not easy to say how far such indications are of specific importance. Bearing in mind the difficulties which are caused by difference of matrix and *status* of the fossils, it cannot be expected that identifications should be more than approximate. In the Corallian of Yorkshire, *i.e.* in the Coral Rag of Ayton and the Coralline Oolite of Pickering, this section of *Trochus* is represented by *T. Aytonensis*, Bl. and H. (see Cor. Gast. GEOL. MAG. 1881, Pl. III. Fig. 12). This is a still smaller species, with a wider spiral angle, having three tuberculated spirals, the nodes in the uppermost one being the strongest: moreover, the basal belt is more prominent in the Corallian species.

T. monilitectus has never, to my knowledge, been found in the Yorkshire Dogger. It is quoted by Brauns from three horizons of the Middle Jura in N.W. Germany. But judging from the synonyms which he gives, this identification must be received with caution.

75.—TROCHUS SCARBURGENSIS, sp.n.[1] Plate III. Figs. 2, 2*a*.

Description.—Specimen from the Cornbrash (zone 4), Scarborough. Leckenby Collection.

Height	17·5 millimètres.
Width	15 ,,
Spiral angle	70°.
Ratio of body-whorl	52 : 100.

Shell conical, imperforate, slightly turrited: spire consists of about six whorls, which are perfectly flat: suture close, sutural line but little inclined. The angle of increase is extremely regular, and each whorl is ornamented by five richly cut tuberculated spirals, with interspaces about 1½ times the breadth of each spiral: in the body-whorl these interspaces are both relatively and actually wider, and are striated obliquely to the axis, *i.e.* from left to right. The tubercles are small and globular, but become more irregular and extended in the spirals of the body-whorl.

The posterior spiral in each whorl is slightly the most prominent, standing forward distinctly from the base of the preceding whorl, so as to produce a slight tabulation. In the body-whorl the lowest, or fifth spiral is supplemented by fine undulating lines, the whole forming a broad belt which margins the base. This is tumid, and ornamented with spiral lines or striæ, slightly decussated by radial lines: the spiral striæ are not continued into the columellar area, which is very thick and solid. Aperture subquadrate, and but little depressed. Other indications wanting.

Relations and Distribution.—This very pretty and regular *Trochus* is distinguished from *T. monilitectus* by its larger habit of growth and wider spiral angle, by the slightly tabulate character of each whorl, and by the greater space between the spirals: also by the relatively shorter spire. It has closer affinities with *Trochus*

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[1] This specimen is in a small tray mounted on a tablet in the Woodwardian Museum. The tablet is labelled "*Trochus*, Cornbrash, Scarbro'." The tray also contains a MS. note, apparently in the handwriting of the late Dr. Lycett, which runs thus: "A (?) Fistulana figured by Deslongch. from the For. Marble of Langrune is probably the same as your rare Cornbrash one." At present I have not been able to ascertain what reference is here intended. One rarely gets a fossil in such good preservation as this: hence, I have ventured to distinguish it.

strigosus, but besides being smaller (the figure of *T. Scarburgensis* in Plate III. is enlarged, whereas those of *T. strigosus* are natural size), the spiral angle is wider, the tuberculations are finer and sharper, and the whorls of the spire are devoid of the basal belt, which is seen in most specimens of *T. strigosus*, and which occasionally assume exaggerated dimensions (see Fig. 4). Nevertheless, unless the specimens are well preserved, it is by no means easy to distinguish in all cases whether some of the smaller specimens referred to *T. strigosus* should not be placed here. On the other hand, subsequent investigation may serve to show that *T. Scarburgensis* is merely a variety of *T. strigosus* with a wider base, finer ornaments, and with the whorls of the spire less exposed.

76.—TROCHUS STRIGOSUS, Lycett, 1863. Plate III. Figs. 3, 3*a*, and 4.

1863. *Trochus strigosus*, Lycett, Suppl. Gt. Ool. Moll. p. 29, pl. 45, fig. 12.

Bibliography, etc.—This species was described from a single specimen, obtained in the Cornbrash of Gristhorpe Bay, in the collection of Mr. Leckenby.

Descriptions.—Specimen from the Cornbrash (zone 4). Leckenby Collection. TYPE REFIGURED. Figs. 3 and 3*a*.

Height	23·5 millimètres.
Width	20 ,,
Spiral angle	65°.
Ratio of body-whorl	46 : 100.

Shell conical, imperforate. Spire consists of about 5 or 6 whorls, which are nearly flat, and separated by a tolerably close suture. The ornaments consist of five spirals, of which the four posterior ones are granulated and nearly equal: the fifth or anterior spiral becomes a broad belt consisting of one row of fine granulations, and two or three raised lines which are not granulated: the ornaments of the body-whorl are similar in character, the basal belt being very wide. (In other specimens the spaces between the spirals of the body-whorl are striated obliquely to the axis. This feature is perhaps more apparent in the worn than in the better preserved specimens.)

Base tumid, with a system of spiral lines or striæ, which extend well up to the columellar area, and are strongly decussated by radial lines. Aperture subquadrate, and but slightly depressed.

Another specimen.—Same horizon, locality, and collection. Fig. 4.

Height	36·5 millimètres.
Width	30 ,,
Spiral angle	63°.
Ratio of body-whorl	50 : 100.

This is a rugose specimen where the features above described in the type are exaggerated. The basal belt is greatly enlarged, and projects so as to give the shell a sort of reversed turriting.

Relations and Distribution.—Somewhat more rugose and irregular than either of the preceding species, with a larger habit of growth. In *T. strigosus* the cone is less perfectly regular: moreover, the basal belt in each whorl projects considerably, presenting a feature the converse of that in *T. Scarburgensis*, where the salience is due to the projection of the posterior border of each succeeding whorl. In smaller specimens the spiral angle is rather wider: hence there is very little difference in this respect between *T. Scarburgensis*, and small specimens of *T. strigosus*.

There is a tablet in the Leckenby Collection which contains half a dozen specimens referred to *T. strigosus*, and a few may be seen in other collections. Hitherto only found in the Cornbrash of Gristhorpe.[1]

77.—TROCHUS SUBGLABER, sp. n. Plate III. Figs. 6, 6*a*.

But compare—

Trochus glaber, Koch and Dunker, Verstein. p. 24, pl. i. fig. 12, from the Lias.
Trochus Dunkeri, Morr. and Lyc., Gt. Ool. Moll. p. 61, pl. x. fig. 3.

Description.—Specimen from the Cornbrash (zone 4), Scarborough. Leckenby Collection.

Height	13 millimètres.
Width	10 ,,
Spiral angle	52°.
Ratio of body-whorl	40 : 100.

Shell small, conical, (?) imperforate; spire consists of 6 or 7 whorls increasing pretty regularly under an angle of 52°; suture close, but very distinct. Anterior area of each whorl slightly tumid, posterior area slightly constricted; the effect of this is to cause each whorl slightly to overhang the succeeding one.

The ornaments consist of fine spiral striæ, very numerous and somewhat closer together in the anterior than in the posterior region; these striæ are decussated by backward sloping transverse striæ, which scarcely reach the anterior margin. Base flat; other indications wanting.

Relations and Distribution.—It is quite possible that this very elegant little shell approaches *T. Dunkeri*, said by the authors of the Great Oolite Mollusca to be tolerably abundant in the White Stone of Eastcombs and Bussage. It differs in possessing more whorls, and also in having a fine system of ornamentation which has been well preserved in the waxlike calcite of the Yorkshire Cornbrash. This might not be equally well preserved in another matrix. As regards *T. glaber*, K. and D., there is probably a still wider margin of difference: it should also be mentioned that Eugène Deslongchamps, in 1860, expressed his opinion that Koch and Dunker's species was a Pyramidellid belonging to the genus *Niso*.

Trochus subglaber is confined, as far as I know at present, to the

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[1] On looking over the Bean Collection at the British Museum, I found a specimen of *Trochus* in an indurated gritty marl of a grey colour, which might be either Cornbrash or Kelloway Rock—most probably the latter. This fossil is evidently allied to the group just described (see Plate III. Fig. 5).

The spiral angle is about 65°–70°. There is no projection of the basal belt; on the contrary, the sudden increase is just below the suture, as in *T. Scarburgensis*. In the body-whorl the spaces between the spirals are remarkably wide, and besides the usual oblique axial striation, fine spiral lines may be noted between the more prominent spirals. A similar feature may be noted in a *Trochus* belonging to the Yorkshire Philosophical Society, which is either from the Cornbrash or Kelloway Rock. Shall we give these a temporary distinction as *T. Scarburgensis*, var. *interlineatus*?

Cornbrash of Yorkshire, and the specimen in the Leckenby Collection is unique.[1]

78.—TROCHUS? LECKENBYI, Morris and Lycett, 1850. Plate III. Fig. 7.

1850. *Trochus ? Leckenbyi*, Morr. and Lyc. Gt. Ool. Moll. p. 115, pl. 15, fig. 21.

Bibliography, etc.—The authors appear to have had a suspicion that this was a *Pleurotomaria*, but observed nothing upon the surface of the whorls to indicate that such was the case.

Description.—Specimen from the Scarborough Limestone (zone 3), near Scarborough. Leckenby Collection. TYPE REFIGURED.

Height	15 millimètres.
Width	17 ,,
Spiral angle	85°.
Ratio of body-whorl	50 : 100

Shell short, conical, imperforate. Spire regular, and consisting of about 5 whorls, which are nearly flat: suture rather close. The ornaments have suffered somewhat from attrition: they consist of stout granulated spiral bands, those towards the base of each whorl having a slight prominence: the system of transverse decussation is somewhat obscured by the conditions of preservation. The body-whorl shows a slight prominence at the margin.

Base nearly flat, with strong spirals decussated by radiating lines. Aperture trapezoidal, depressed.

Relations and Distribution.—No other specimen is known to me at present, nor could I say for certain whether this is a *Trochus* or a *Pleurotomaria.*

Genus PLEUROTOMARIA, Defrance, 1825.

Nothing can be more complete and surprising than the contrast presented by the extraordinary poverty of the whole of the Lower Oolites of Yorkshire in regard to this genus, and the wonderful abundance of *Pleurotomaria* in the Inferior Oolite of Dorset-Somerset. The rich shell-bed of the Dogger, which has furnished something like half the species described in this Memoir, does not contain a single *Pleurotomaria;* but there is one very large species allied to, if not identical with *Pl. anglica*, Sow., which is rarely found in the lower portions of the Dogger, and possibly also in the Dogger Sands. It is usually regarded as a Liassic species, and is quoted by Tate and Blake under the title of *Pl. undosa* and amongst the eleven species enumerated by them from the Yorkshire Lias. If not exactly the

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[1] There is another specimen placed on the same tablet which appears to me to represent a smaller and more coarsely ornamented species, or at any rate a well-marked variety (not figured); also from the Cornbrash. The following is the description.

Height	10 millimètres.
Width	8 ,,
Spiral angle	50°.

The number of whorls is about 7 or 8. The angle of increase is very slightly convex, whorls nearly flat: suture very distinct. The ornaments consist of about 7 strap-like spirals, slightly granulated, and separated by very narrow and shallow sulci. A raised belt with spiral lines slightly granulated terminates the flank of the body-whorl, thus constituting the basal periphery. Base flat; other indications wanting.

same, it clearly belongs to a well-known Liassic group. If we except this and the very doubtful *Trochus Leckenbyi* which may be a *Pleurotomaria*, there are no other representatives of the genus in any of the three zones of the Inferior Oolite of Yorkshire. But the Dogger contains rather abundantly one species of the allied genus *Trochotóma*—the widely-ranging *T. calix*.

From the Cornbrash upwards *Pleurotomaria* is rather better represented, and one species is quite abundant; but this has affinities with Oxfordian rather than with Lower Oolite forms of other districts. For further observations with respect to the higher beds see Corallian Gasteropoda (Geol. Mag. 1881, page 63 of separate Memoir).

79.—PLEUROTOMARIA GRANULATA. Lycett, non Sow., 1863. Plate III. Figs. 8, 8*a*, 8*b*, 9, and 10.

1863. *Pleurotomaria granulata*, Sow., Lycett, Suppl. Gt. Ool. Moll. p. 24, pl. 31, fig. 8.

Compare also

Pleurotomaria Münsteri, Rœmer, 1839, Ool. Geb. p. 44, pl. 20, fig. 12.
,, *punctata*, Goldfuss, 1844, t. 186, fig. 6, non Sow.
,, *Aonis*, D'Orb., Brauns, Mit. Jura, p. 188.
,, species, Hudleston, Cor. Gast., Geol. Mag. 1881, Pl. IV. Fig. 2.

Bibliography, etc.—The true *Pl. granulata* of Sowerby is an Inferior Oolite fossil well known to every collector from the beds in Dorset and Somerset, and differs considerably from the species now under consideration. I have already discussed this question at some length in the Corallian Gasteropoda (p. 64 of separate copy), with reference to a specimen of *Pleurotomaria* from the Lower Corallian Limestones of Wydale. It is true that our Cornbrash fossil belongs to what Prof. Seeley would call a "demoid" type, which has connection through varieties with Sowerby's I. O. species. But the inspection of a large number of I. O. specimens convinced me long ago, as it did the late Mr. Tawney, that the Yorkshire specimens referred to *Pl. granulata*, Sow., must be regarded as specifically distinct. Not only so, but the fossils of the Yorkshire Cornbrash approach much nearer to *Pl. Münsteri*, Rœm., as also does the fossil from the Lower Limestones of Wydale.

The specific names "*granulata*," *reticulata*, *fasciata*, etc., have been bestowed in former years with such a liberal hand that the mind becomes somewhat fogged in its endeavours to remember the various authors and their identifications. It is difficult to say whether most mischief is done by retaining such names, by adopting others already existing which are nearer the mark, or by inventing fresh ones. As the present is a work confined mainly to the illustration of local palæontology, it has been considered best to adopt the first course. At the same time I am perfectly aware that it leads to confusion, and that *Pl. granulata*, D, non A, non B, non C, is a stumbling-block to students and a sad tax upon the memory of all.

Descriptions.—Specimen from the Cornbrash (zone 4), Scarborough. Leckenby Collection. Figs. 8, 8*a*, 8*b*.

Height	24·5 millimètres.
Width	26 „
Spiral angle	78°.
Ratio of body-whorl	48·100.

Shell short, step-like, with the rudiments of an umbilicus. Body-whorl about half the height of the spire. Whorls about 6 in number, angular, sloping in the posterior two-thirds, nearly vertical (*i.e.* parallel to the axis) in the anterior third. The ornaments consist of numerous fine spirals which present nodes at the points of contact with the fine transverse lines which decussate them, the result being a very pretty reticulation with a fine mesh. The spirals are not exactly of equal strength: for instance there is a hollow beneath the carina, in the bottom of which is a very fine spiral line quite plain; a little distance below this, and almost at the base of the whorl, a pair of strongly granulated spirals constitute the rudiments of a belt or lower carina. (Some of these features can only be recognized in exceptionally well-preserved specimens.) The principal carina, which occurs about two-thirds down, carries the imbricated slit-band; this occupies the most salient position in each whorl.

Base tolerably tumid, with strong spiral ornaments, less conspicuously decussated than on the flanks of the shell. Aperture subquadrate or trapezoidal, columellar lip thick and curving forwards.

Another specimen.—Kelloway Rock (zone 5), Scarborough. Leckenby Collection. Fig. 9.

The condition is not favourable for close description; moreover, the specimen has the appearance of having been slightly compressed. The outline and ornaments are sufficiently distinct to make it clear that there can be no differences of importance from average Cornbrash specimens. The position of the slit-band in the keel at the angle of the whorls is also equally obvious. If there is any structural difference, it consists in the slightly more sloping outline of the anterior third; but this I consider to be the result of compression.

Another specimen.—Oxford Clay (zone 6), Scarborough. York Museum. Fig. 10.

Still more compressed than the last, and in what may be termed a "half-cast" condition, though better than many fossils from the "Oxford Clay" of Scarborough Castle Hill. The nodes at the intersections having been worn nearly flat, the ornaments are in a reticulate condition, and this is also the case with the Kelloway Reck specimen.

N.B.—Very large specimens from the Cornbrash have a height of 4½ centimètres, and such are slightly more pyramidal than the average forms. A specimen in Mr. Leckenby's collection must have had 9 or 10 whorls, and there is a somewhat similar specimen in the Scarborough Museum. In these large specimens the "granulate" character is almost entirely effaced, and the "reticulate" character prevails.

Relations and Distribution.—The relations of a thoroughly demoid type are pretty wide, though no species of *Pleurotomaria* resembling this one occurs on any lower horizon in Yorkshire. But, as we have seen, it is easy to trace this form upwards through the Kelloway

Rock and Oxford Clay into the Lower Corallian Limestones. The larger specimens have a considerable resemblance to *Pl. Münsteri* from the "Lower Coral Rag" of Heersum, which is on the horizon of the Wydale Beds. In *Pl. Münsteri* the spiral angle is wider, the whorls more angular, and the ornamentation probably more "reticulate" (mainly a question of *status*). The closest representatives of *Pl. Münsteri* occur in the Main Limestones of Osmington. But in the Elsworth rock, which is Upper Oxfordian, are specimens of *Pleurotomaria* the very fac-simile of the larger specimens from the Scarborough Cornbrash. These Elsworth rock specimens were identified by Blake and Hudleston (Corallian Rocks of England, Q.J.G.S. 1877, p. 313) with Rœmer's Heersumer species.

The specimen from the Lower Corallian Limestones of Wydale is in excellent preservation, and may be compared even with such an one as is figured (Plate III. Fig. 8). Although a smaller fossil, the granulations are slightly larger, and in this respect it more nearly approaches *Pl. granulata*, Sow. I doubt not that each horizon and locality will present some slight differences, but the broad fact remains that one of the most abundant fossils in the Yorkshire Cornbrash may be traced sparingly through all the Oxfordian beds of Yorkshire, including the Lower Corallian Limestone, whilst its nearest relatives, and in some cases absolute representatives, are characteristic Oxfordian fossils in other places.

EXPLANATION OF PLATE III.

Fig. 1, 1*a*, 1*b*.	*Trochus monilitectus*, Phillips. Scarborough Limestone. British Museum. Back, front, and basal views. × 1½.
" 2, 2*a*.	*Trochus Scarburgensis*, sp.n. Cornbrash, Scarborough. Leckenby Collection. Back and front views. × 1½.
" 3, 3*a*.	*Trochus strigosus*, Lycett. Cornbrash, Scarborough. Leckenby Collection. Type refigured. Back and front views: nat. size.
" 4.	*Ib.* Same formation, locality, and Collection. Back view; nat. size.
" 5.	*Trochus ? Scarburgensis*, var. Cornbrash or Kelloway Rock. British Museum. Back view; nat size.
" 6, 6*a*.	*Trochus subglaber*, sp n. Cornbrash, Scarborough. Leckenby Collection Back view. × 1½, and whorl further enlarged.
" 7.	*Trochus Leckenbyi*, Morris and Lycett. Scarborough Limestone, ? Claughton. Leckenby Collection. Type refigured. Back view. × 1½.
" 8, 8*a*, 8*b*.	*Pleurotomaria granulata*, Lycett, non Sowerby. Cornbrash, Scarborough. Leckenby Collection. Back and front views; nat. size, and portion magnified.
" 9.	*Ib.* Kelloway Rock, Scarborough. Leckenby Collection. Back view; nat. size.
" 10.	*Ib.* Oxford Clay, Scarborough. York Museum. Back view; nat. size.

IV.—On the Recent Discovery of the Wing of a Cockroach and two Scorpions in Rocks of Silurian Age.

By Herbert Goss, F.L.S., F.G.S., etc.

Up to December last the most ancient fossil insects known were the six fragments of *Neuroptera*, obtained by Mr. C. F. Hartt, from the Devonian rocks of New Brunswick, which were described by Mr. Scudder in Vol. V. of this Magazine.[1] Although these six fossils were the oldest *known* insects, it seemed unlikely that they, or even the families or genera to which they belonged, were the most ancient representatives of their class. The first appearance of insects on the Earth was probably contemporaneous with that of land plants, and as remains of this division of the Vegetable Kingdom had been discovered in Silurian rocks, it seemed not unreasonable to assume that insects might have existed at an earlier period than the Devonian. The recent discovery of the wing of a cockroach in rocks of Silurian age at Jurques, Calvados, France, no longer leaves the question of the occurrence of insects at an earlier period than the Devonian a matter of speculation.

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[1] 1868, pp. 172-177, and 216-222.

In a note, recently communicated by M. Milne-Edwards to the Académie des Sciences of Paris,[1] M. Charles Brongniart describes the wing of a species of *Blatta* from the Middle Silurian formation of Jurques. The piece of rock containing this fossil was received from M. Douvillé, Professor in the Paris School of Mines, in whose honour this *the oldest known insect* has been named *Palæoblattina Douvillei.*

M. Brongniart states that the neuration of two species of *Blattidæ*[2] of the Carboniferous Period—*Progonoblattina Fritschii* (Heer) and *Gerablattina fascigera* (Scudder)—recalls, in a slight degree, that of this Silurian wing which he describes as follows:—

> "Cette aile qui mesure $0^{m},035$ de long a appartenu à un *Blattide;* le champ huméral est large; on y voit la veine humérale supérieure, la veine humérale inférieure qui se bifurque à son extrémité; la veine vitrée ou médiane également divisée en deux rameaux; les veines discoïdales supérieure et inférieure et leurs divisions très obliques qui se rejoignent à leur extrémité, ainsi que cela se voit encore chez certaines Blattes de notre époque; on peut suivre la veine anale qui est assez droite et s'étend presque jusqu'au bout de l'aile, puis les veines axillaires qui lui sont paralleles. Ce qui est fort remarquable et ce qui distingue cette émpreinte de toutes les ailes de Blattes vivantes et fossiles c'est la longueur de la nervure anale, et le peu de largeur du champ axillaire."

Although the fossil wing above described is the only fragment of an *insect* as yet obtained from rocks of Silurian age, the recent discovery of insectivorous animals—two scorpions—in Silurian rocks furnishes additional evidence of the existence of insects at this early period.

One of the Scorpions was obtained by Dr. Hunter, of Carluke, from the Ludlow beds (Upper Silurian) of Lesmahagow, Lanarkshire; and a preliminary description of it by Mr. B. N. Peach has appeared in a recent number of "Nature."[3]

The second Scorpion was obtained from the Upper Silurian of the Isle of Gotland, and has been named by Dr. Lindström *Palæophonus nuncius*, and described by him in a letter to M. Milne-Edwards,[4] which the latter has communicated to the French Academy of Sciences. Dr. Lindström states that this Scorpion is in a good state of preservation. and that one of the stigmata is visible on the right side, clearly proving that the animal respired air. He further remarks that in the construction of this Scorpion a feature of great importance is observable, viz. the presence of four pairs of thoracic legs which are stout and pointed like those of the embryos of many *Tracheata* and of forms like *Campodea*. This form of the leg no longer exists in the fossil Scorpions of the Carboniferous formations, in which fossils these appendages resemble those of existing species.

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[1] Comptes rendus des Séances de l'Académie des Sciences de Paris, No. 26, 29th December, 1884.

[2] These *Blattidæ* are referred to in my paper on "The Insecta of the Carboniferous Period," pp. 169-173, of vol. xv. of the Entomologists' Monthly Magazine, 1878, and "The Insect Fauna of the Primary or Palæozoic Period," Proc. Geol. Assoc. vol. vi. No. 6, 1879.

[3] No. 796, January 29, 1885.

[4] Extract from a letter from Prof. Lindström to M. Milne-Edwards, Comptes Rendus of the Académie des Sciences of Paris, No. 22, 1 Dec. 1884, pp. 984-985. Dr. Lindström states that a detailed account of this Scorpion by Prof. Thorell and himself will shortly appear.

It will be noticed that both these Scorpions were obtained from the *Upper* Silurian, whereas the wing of the Cockroach was, as before stated, obtained from the *Middle* Silurian (Silurien Moyen). This wing is therefore of even greater antiquity than the Scorpions, and consequently represents not only the oldest known *insect*, but the oldest known *terrestrial* animal.

The discovery of air-breathing land animals in the Silurian rocks is of course of importance to geologists from the evidence thus afforded of the terrestrial and atmospheric conditions of the period; and the fact that the ancestors of the ubiquitous Cockroach were the most ancient representatives of the class *Insecta*, and of all land animals, cannot but be interesting to zoologists.

V.—NOTE ON AN APPARENTLY NEW SPECIES OF *HYOPOTAMUS* (*H. PICTETI, NOBIS*).

By R. LYDEKKER, B.A., F.G.S., etc.

SINCE describing the skull of *Anthracotherium Gresslyi* (=*Hyopotamus Gresslyi*. Rüt.) in the last Number of the Magazine (p. 63), I have observed that the right maxilla of a small anthracotheroid from the Upper Eocene "Bohnerz" of Canton Vaud, Switzerland, has been figured by Pictet in his "Matériaux pour la Paléontologie Suisse—Vertèbres de la Faune Eocéne, Supplement, pl. xxiv. fig. 5," under the name of *H. Gresslyi*. The British Museum has recently acquired some upper true molars from the same formation agreeing precisely with those of Pictet's specimen; and a comparison of these teeth with those of the Brit. Museum specimen of *A. Gresslyi* (figured in my memoir already quoted) shows that they are quite different;—being distinguished by their slightly inferior size, the more inward inclination of the outer surfaces of the external columns, as well as the more distinct loop connecting these columns. These teeth agree, in fact, with those of brachydont species of *Hyopotamus*, like *H. porcinus*. Pictet's figure also shows that his specimen differs from *Anthracotherium Gresslyi* in having an elongated, instead of a triangular pm. $\underline{3}$.

There is no question of the distinctness of the form under consideration from the last-named species, and as its molar teeth are precisely similar in structure to those of the much larger *Hyopotamus porcinus*, it may be at least provisionally referred to the same genus. As I am unable to identify it with any named form, it may receive a new specific name, and I accordingly propose that of *H. Picteti*.

VI.—CONTOUR-LINES ON GEOLOGICAL MAPS.

By Prof. BENJAMIN SMITH LYMAN.

AS one of your reviewers now some years ago criticized unfavourably the method of representing geological structure in maps by contour lines upon a bed of coal or other rock, and as, like him, most geologists are not yet practically familiar with the method, useful though it be, and nobody that might be thought wholly unbiassed has replied in your pages to his attacks, it may not be improper to call your attention to the unprejudiced opinion and explanation of Mr. Charles A. Ashburner, the geologist in charge of the survey of the anthracite region, under the Geological Survey of Pennsylvania, who has up to this time published 26 large sheets of most elaborate maps and sections with one volume of text. After careful examination before adopting the method and after using it several years he writes of it in the report (page 8) as follows:—

"The first time the system has been used on an extensive scale in America has been in the construction of the mining geological sheets of the anthracite coal fields. The data which are available for constructing these maps are very extensive and very accurate. The method has been found to furnish the best means for interpreting the geological structure and the best way of representing it; so that in this the demands of the geological investigator are satisfied. At the same time that this end is accomplished, the facts relating to the structure of the coal bed in the mines and adjoining tracts are best classified and placed in such a form as to be of practical use to the mine superintendent and engineer.

"The information which a geological mining map constructed on this plan contains relative to the coal bed which is contoured may be classified under the following heads: *a*, elevation above tide of the coal outcrop; *b*, dip of the bed; *c*, strike of the bed; *d*, depth of the coal basins; *e*, rate of fall or rise of the basins along their axes; *f*, position of the synclinals and ancticlinal crests in the coal bed; *g*, data from which a vertical cross-section may be made at any point across the basins; *h*, data from which the absolute area of the coal bed may be obtained, and the amount of coal contained in any special surface area estimated.

"*a*. In order to obtain the elevation of the outcrop at every point, it is necessary that the bed should be contoured on a topographical map of the surface as a basis.

"*b*. The horizontal distance between the contour curves represents the cosine of the angle of the dip . . .

"*c*. The direction of the contour curves shows the strike of the bed and the direction of the gangways which have already been driven, or the most probable direction which approximately level gangways will assume if driven beyond the present mined area.

"*d*. The most probable depth of the coal basins can be better estimated by this method of construction than by any other . . .

"*e*. The rate of rise and fall of the basins along their axes is a very important fact to determine, in order to locate mining works for the exploitation of the deepest part of the basins; and more particularly to establish the best elevation at which to drive gangways to command the greatest area of coal with the least expenditure, for the driving of permanent travelling ways and the lifting of the coal and pumping of the mine water.

"*f.* It is a well-known fact to the practical mining geologist that, ... when the axial plane is inclined, the axis in the outcropping strata may be many feet to one side or the other of a vertical plane passing through the axis in the coal bed.

"*g.* It is apparent that a vertical section of the contoured coal bed may be constructed directly from the curves, running across the basin in any direction. The position on the section plane of the overlying and underlying strata may be located from columnar sections.

"*h.* One of the most important applications of this method of construction is the estimation of the absolute areas of the coal beds under any given tract, and consequently the coal contained. It is readily perceived that consequently, when the contoured surface of the bed is developed or ironed out into a horizontal plane, allowance will have been made for every degree of dip which the bed possesses in its true position, and the real area of the bed on the flat will be shown."

On the Mine Sheets so far published the underground workings of several coal beds are given in different colours, besides the contours of the floor of the principal bed, and "the confusion and unsightliness of so many lines upon a map," complained of by your critic, is not enhanced by the addition of the contours of the surface of the ground, for (p. 15) "the topographical maps which have come into the possession of the Survey have not been found sufficiently accurate to make it possible to combine them in this way with the mine sheets constructed by the Survey corps, without completely revising them on the ground. As the restricted means of the Survey have prevented this revision, it was decided to publish these maps separately, and on one-half the scale of the Mine Sheets, in order to reduce the cost of publication. The difference of scales makes a comparison of the two sets of sheets inconvenient.

"Before the completion of the Geological Survey of the Anthracite Fields, it is hoped that surface contour curve maps may be constructed by the corps of the following areas. . . . . In some of these areas the contours of the surface can no doubt be placed to advantage on the mine sheets without overloading the map to such an extent as to produce confusion."

Of course "confusion and unsightliness" depends much upon the experience of the reader, and a mere contour map of the surface will have that character to anybody unaccustomed to contours. While real confusion is certainly to be avoided, a good deal of what seems at first unsightliness may be pardoned if compensated by usefulness and convenience in use. Indeed, there is much truth in the common saying that "handsome is that handsome does"; for our ideas of beauty are at the very bottom altogether based upon fitness for our needs. It seems at least possible that the most crowded mine sheets like Mr. Ashburner's with the coal contours in red, complicated as they sometimes are with overturned dips, might besides advantageously have surface contours in rather fine black lines, or in some other colour.

NORTHAMPTON, MASS.

NOTICES OF MEMOIRS.

DIE EISZEIT IN DEN PYRENÄEN. Von DR. ALBRECHT PENCK. Mit einer Karte. Mittheilungen des Vereins für Erdkunde zu Leipzig, 1883.

THE GLACIAL PERIOD IN THE PYRENEES. By Dr. ALBRECHT PENCK. With a Map. (Transactions of the Geographical Society of Leipzig, 1883.)

THIS paper contains the general results of an investigation of the ancient glacial phenomena of the Western Pyrenees, from San Sebastian on the Atlantic coast to Montrejean on the Garonne, undertaken with the object, amongst others, of determining the approximate level of permanent snow at the time of the greatest extension of the glaciers. Of this, the author's previous experiences in the Alps, Scandinavia and Great Britain render him well fitted to judge. He incidentally remarks that the similarity between the glacial phenomena of the Pyrenees and those of the countries just named are very striking.

It has been stated by various authors, amongst others by Habenicht and von Hochstetter, that the valleys of the western end of the Pyrenees had been formerly filled by ice; but Dr. Penck asserts that there is not a trace of glaciation in the valleys of the affluents of the Bidassoa, the Nive, and the Urumea, although the indentations of the coast near San Sebastian and Fuenterrabia have a distant resemblance to fiords. Although the highest peaks in this district reach an elevation of 1400 m. (4600 feet), there are neither cirques, tarns, nor moraines to be found, and their absence proves that in this locality the line of permanent snow (Fernlinie) during the Glacial period was at all events above this level. It is true that in places there are huge boulders and scratched stones which have been attributed to glaciers, but their distribution is very limited, and they may be traced to the effects of landslips.

The valley of the Saison is the most westerly on the French side of the range in which glacial action appears. The average elevation of the mountains which drain into it is 1740 m. (5707 feet), and the old moraines can be traced to the level of 581 m. (1905 feet). In the valley of the Aspe, to the east of the Saison, a moraine exists at the level of 410 m. (1344 feet), and below this is a distinct basin now filled up with gravels. Further eastwards, in the valley of the Ossau, a terminal moraine has been noted at 350 m. (1148 feet), but even below this level, scratched stones and moraines have been noted, so that in the Pyrenees, as in the Alps, there is an outer zone of moraines distinct from the so-termed end-moraine, and a great accumulation of gravels was formed in the interval between the deposition of the outer moraines and the later end-moraine.

Further to the eastward the important glaciers of the valley of Argelès and of Aure are described, and then the glaciers of the Garonne, the most important of the Pyrenees. The portion of the range drained through this valley has an average elevation of 2560 m. (8400 feet). From the evidences of the ice action in the higher districts of the Garonne, the conclusion is arrived at that the line of permanent snow in the Glacial period was about 1700 m. (5576 feet).

On the south side of the Pyrenees the author describes the course of two of the ancient ice-streams; that of the valley of the Gallego, which had a length of 45 kilom., and that of the Ara valley 40 kilom. in length. These correspond with the glaciers of Ossau and Argelès on the north side, which have respectively an extension of 40 and 55 kilom., but whereas these latter advance beyond the foot of the mountains to the level of 400 m. (1312 feet), the former, on the south side, do not descend below 800 m. (2624 feet).

The ancient glaciers on the south side of the Pyrenees, not only terminated at a higher level, but they were also far shorter than those on the north side, and these differences arise, not from the configuration of the ground, but in the different intensity of the glacial phenomena on the two sides. It is therefore probable that the ancient snow-line on the south side was 300 m. higher than on the north, or at a level of 2000 m. (6560 feet). The ancient snow-line was also higher from west to east, and the evidence shows that the ancient phenomena were developed under similar conditions to those now existent, and may be considered as an intensification of the present.

Sections showing glacial deposits of different periods do not occur in the Pyrenees, as almost everywhere the moraines rest directly on the older rocks, but indirect evidence of more than a single glaciation is shown by the enormous accumulations of gravels, clearly of different ages, which cover the surface beyond the base of the mountains on the north side, sometimes reaching a thickness of over 100m. (328 ft.).

The concluding part of this important paper contains some suggestive reflections on the development of the cirques and smaller lakes in the higher portion of the Pyrenees and their relations to each other. A list of the directions of the glacial striæ observed by the author is given in an appendix; and a map of the Pyrenean range and the country on both sides, in which the glaciated areas are distinctively coloured, is of great service in following the author's descriptions. G. J. H.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

January 28, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair. The following communications were read:

1. "The Boulder-clays of Lincolnshire: their Geographical Range and Relative Age." By A. J. Jukes-Browne, Esq., B.A., F.G.S.

The author commenced by referring to the late Mr. Searles V.

Wood's papers on the Glacial beds of Yorkshire and Lincolnshire, and stated as the result of his own investigations, that two distinct types of Boulder-clay occur in Lincolnshire, (1) the grey or blue clay, (2) the red and brown clays, the former undoubtedly an extension of the Upper or Chalky Boulder-clay of Rutland and East Anglia, while the second includes the Purple and Hessle Clays of Mr. S. V. Wood. These two types of Boulder-clay are very rarely in contact with each other.

The brown Boulder-clays of East Lincolnshire rest upon a broad plain of Chalk, which appears to terminate westward in a concealed line of cliff, this cliff-line coinciding with the strike of the slope which descends from the Chalk Wolds to the Boulder-clay plateau by which they are bordered. The present boundary-line of the Boulder-clay runs along this slope for long distances, though in many places the clay has surmounted the slope and caps the hills to the west of it.

From Louth the main mass of the "brown clay" is bounded by a line drawn through Wyham, Hawerby, Laceby, and Brocklesby to Barrow and Barton on Humber, sweeping round the north end of the Lincolnshire Wolds and occurring on both sides of the Humber. Previously to the author's inspection of this district, no Purple or Hessle clay had been discovered west of South Ferriby, and these clays were supposed to be entirely absent on the western side of the Wolds. The officers of the Survey have, however, mapped several tracts of such clay in the valley of the Ancholme. It occupies the surface at Horkstow, Winterton Holme, Winterton, and Winteringham. It probably underlies the alluvium of the Ancholme near and south of these places, and occurs again at higher levels in the neighbourhood of Brigg. South of Brigg it has been seen at low levels on either side of the valley of the Ancholme, as far as Bishop's Bridge, near Glentham.

Beyond this point it was not traceable in the Ancholme valley, but south of Market Rasen patches of reddish-brown clay, mottled with grey, and containing small flints and pebbles of chalk occur, and cap the low ridges separating the valleys of the brooks.

Another tract of Boulder-clay, which the author considers to belong to the same series, occupies the western border of the Fenland, S.E. of Lincoln, what is left of it forming a ridge which runs southward for many miles. It passes eastward beneath the Fen deposits; and similar mottled clay was seen in the excavations for the Boston docks beneath about 20 feet of Fen-clays, etc., and resting upon blue Boulder-clay of the "Chalky" type. Beside this section at Boston, there are very few places where the two types of clay are in contact, or so near as to afford any evidence as to their relative age. Near East and West Real, and again near Louth, the "Brown Clays" are banked against the slopes of hills which are capped with the "Chalky Clay." The same is the case also near Brigg, where the country seems to have been originally covered by a sheet of the Chalky Clay, through which valleys were eroded into the Jurassic clays, and the brown (Hessle) clay is found only in these valleys. The author concludes, therefore, that the "Brown-clay series" is of much newer date than the "Blue and grey series."

In conclusion, the author summed up the inferences drawn in the paper, correlated the Basement Clay of Holderness with the Chalky Clay of Lincolnshire, and suggested that the Purple Clay may be confined to the east side of the wolds. The classification he would propose is therefore as follows:—

	Lincolnshire.	Yorkshire.
Newer Glacial	Hessle Clay.	Hessle and Upper Red Clay of coast.
	Purple Clay.	Purple Clay.
Older Glacial =	Chalky Clay.	Basement Clay.

(*Report to be continued.*)

II.—REPORT OF THE MEETING OF THE GEOLOGISTS' ASSOCIATION, January 2, 1885.

ON SOME RECENT VIEWS CONCERNING THE GEOLOGY OF THE NORTH-WEST HIGHLANDS. By HENRY HICKS, M.D., F.G.S., President of the Association.

THE author stated that as the Proceedings of the Association contained several papers, dealing with the controversy concerning the rocks of the North-West Highlands of Scotland, he thought it advisable to call the attention of the members to views contained in an important article published in "Nature," Nov. 13th, by the Director-General of the Geological Survey; and in a "Report on the Geology of the North-West of Sutherland," by Messrs. Peach and Horne in the same Number, which cannot fail either to change entirely the future character of the controversy, or bring it rapidly to a satisfactory issue. Because of the positions held by the chief disputants on the one side, the controversy had assumed, to a great extent, the appearance of being one between official surveyors and some amateurs who had been led to study the questions involved in it. The well-known and widely-accepted views, first put forward by Sir R. Murchison, that there were clear evidences in the North-West of Scotland of a "regular conformable passage from fossiliferous Silurian quartzites, shales, and limestones upwards into crystalline schists, which were supposed to be metamorphosed Silurian sediments," were fully adopted by the official surveyors, including Sir A. C. Ramsay and Prof. Geikie, also by the late Prof. Harkness and others who had examined the areas. Prof. Nicol, of Aberdeen, however, for many years stoutly contested Sir R. Murchison's views, and maintained that they were based on erroneous observations. Unfortunately his views did not meet with much approval at the time. In 1878 the author reopened the controversy by calling attention to some sections examined by him in Ross-shire, which he maintained did not bear out the views of Sir R. Murchison. He also suggested a modified interpretation of the views of Prof. Nicol. Since then different areas in Ross and Sutherland have been examined by Mr. Hudleston, Prof. Bonney, Mr. Callaway, Prof. Lapworth and Prof. Blake, and their conclusions showed that though slight differences of opinion prevailed on some points, yet with regard to the main questions all were agreed, as to there being no evidence in the areas examined by them to support the Murchisonian views of a conformable upward succession. Many other facts also of great importance were brought out in these inquiries. The author expressed gratification at the candid manner in which the whole question had been dealt with by the Director-General and the Surveyors in their recent report, and at their readiness in acknowledging that, after due examination in the course of surveying and mapping parts of the areas referred to, they had found the "evidence altogether overwhelming against the upward succession which Murchison believed to exist."

CORRESPONDENCE.

THE CLASSIFICATION OF THE JURASSIC SYSTEM.

Sir,—Mr. Blanford states that a line of division drawn between the Cornbrash and the Oxfordian has no general value, "the (lithological) change being confined to but a small part of the earth's surface." England, France and Germany may be only a small part of the earth's surface, but I think most English geologists will be satisfied with a classification of the Jurassic rocks that is applicable to these three countries, and a lithological change does take place about this horizon in all of them.

Mr. Blanford proposes to include the Oxford Clay in the Middle Jurassic and to draw the line of separation between this clay and the Coral Rag, but he does not say whether he would include the Argovien or Lower Calcareous Grit in the former or the latter; he will find that foreign authorities differ, and that either course is unsatisfactory, if the line is to separate divisions of primary rank, the Corallian as a whole being as closely connected with the Oxford as with the Kimmeridge Clay.

In conclusion, let me admit that I stand corrected as to the use of the word "stage"; it should be retained for divisions of secondary rank, and I should not have used it in the sense of a primary division.

A. J. Jukes-Browne.

Jan. 19th, 1885.

OBITUARY.

SEARLES V. WOOD, THE YOUNGER, F.G.S.

Born February 4, 1830. Died December 14, 1884.

Searles Valentine Wood, jun., the son of Mr. S. V. Wood, the well-known palæontologist, was born at Hasketon, in Suffolk, on February 4th, 1830. He was educated first at King's College, London, and afterwards in France. From his boyhood he began to take the liveliest interest in the scientific pursuits of his father. We find him as far back as 1843–5 assisting in the investigations in which Mr. Wood, sen., was then engaged of the Eocene Fresh-water beds of Hordwell Cliff. Indeed he may be said to have been educated upon Tertiary Geology from his youth up. In 1862 he wrote an elaborate paper on "The Form and Distribution of the land-tracts during the Secondary and Tertiary periods respectively, and on the effect upon Animal life which great changes in Geographical configuration have probably produced." It was read before the Geological Society, and was afterwards printed in the Philosophical Magazine. In 1863 he wrote a paper on "The events which produced and terminated the Purbeck and Wealden deposits of England and France," and shortly after, another, on "The Belgian Equivalents of the Upper and Lower Drifts of the Eastern Counties," a third on "The Red Crag and its relation to the Fluvio-Marine Crag and the Drift of the Eastern Counties," and a fourth "On the Formation of the River Valleys of the East of England." In the last of these he enunciated a theory which has received but little attention, but which he strenuously maintained till the last. He was elected a Fellow of the Geological Society in 1864. Having long studied the Glacial beds of East Anglia, he read a paper, in the same year, embodying the results of the work he had carried on in this field, on "The Drift of the East of England." The next year he published, for private circulation, a map of the drift over eight counties, together with remarks in explanation of it; the first attempt which had ever been made to map the Glacial beds, and which, constructed at a time when the Geological Survey ignored these deposits altogether, must be regarded as the parent as well as the predecessor of the many glacial maps which have since been issued. He had been designated for the legal profession, having been admitted a solicitor in 1851, but the death of a gentleman with whom he was associated, in 1865, although leaving a lucrative practice in his hands, gave him an opportunity, which he seized with alacrity, of devoting himself to the elucidation of the Glacial beds. In association with his friend, Mr. Harmer, of Norwich, he spent the following six or seven years in the work, during which time more than 10,000 miles were traversed, and every section of importance in the whole district examined, the results being published by the Palæontographical Society in 1872.

Mr. Wood's mental activity and industry were marvellous. Although during the last ten years of his life a confirmed invalid, so much so as to be for a great part of the time incapacitated from all bodily exertion, and during the summer months from all kinds of literary or mental work; papers of the most elaborate kind were constantly issuing from his study. Previously to his health breaking down, he had, in company with the Rev. T. L. Rome and Mr. Harmer, made several excursions into Lincolnshire, Yorkshire, and the neighbouring counties, for the purpose of studying the Glacial deposits of the North-east of England, the result being published by himself and Mr. Rome, in 1867, in the well-known paper on that subject. In 1870 this was supplemented by another elaborate paper, accompanied by what Sir Charles Lyell called "Miles of Sections," "On the Relation of the Boulder-clay without Chalk of the North of England to the Chalky Clay of the South." In 1867 he had given to the Society an account of his views on the structure of the Post-Glacial beds of the South-east of England, having previously placed in the library at Burlington House a manuscript work of great length on the same subject.

While engaged in the Survey of Norfolk, Messrs. Wood and Harmer had come across a band of fossiliferous sand in the Middle Glacial deposits near Yarmouth, full of comminuted shells, which were in such a fragmentary condition that few species could be determined. Although presenting so much difficulty, the discovery appeared to Mr. Wood so important that he had about two tons of the material sent over to Brentwood, where he then lived, and spent whole weeks in sifting and examining it. The result was the determination of seventy species of Mollusca, several of them being new to science, the whole fauna showing a much older facies than that of the so-called Middle Sands of Lancashire, which had been up to that time regarded as contemporaneous with them.

In 1871 and the following years Mr. Wood continued to write many papers. In 1880 and 1882 he published his last essay on what he preferred to call the "Newer Pliocene Period." Although the best work of his life must no doubt be regarded as that which he devoted to tracing the history of the younger formations of the East of England, yet he nevertheless took the keenest interest in the Glacial and later Tertiary phenomena of other parts of the globe, and in 1877 he published his views on the subject at considerable length in the GEOLOGICAL MAGAZINE. He was meditating a further treatise thereon at the time of his death, although a confirmed invalid, and often racked with pain. The last work in which he engaged was a paper on "The Discovery of the Fossiliferous Beds of St. Erth, in Cornwall," which was read at the Geological Society. His industry was untiring, and considering his feeble health marvellous. Always ready to admit himself in error when the discovery of new facts required it, with a single-hearted desire to ascertain the truth, he was ever willing to place at the disposal of others the knowledge he himself possessed. On the death of his father he was chosen Treasurer of the Palæontographical Society, which office he held until the last. He died on the 14th December, after a few days' illness, at his residence, Beacon Hill House, near Woodbridge, and was buried at Melton Church, in the centre of the district which the labours of his father and himself have made for all time classical ground to students of geology.

The following is a List of Mr. Wood's Papers:—

On the Probable Events which succeeded the Close of the Cretaceous Period. Quart. Journ. Geol. Soc. 1860, vol. xvi. pp. 328–329.

On the Form and Distribution of the Land-Tracts during the Secondary and Tertiary Periods respectively; and on the effects upon Animal Life which great Changes in Geographical Configuration have probably produced. Phil. Mag. 1862, vol. xxiii. pp. 161–171, 269-282, 382–393.

On the Events which Produced and Terminated the Purbeck and Wealden Deposits of England and France, and on the Geographical Conditions of the Basin in which they were Accumulated. Phil. Mag. 1863, vol. xxv. pp. 268–269.

On the Red Crag and its relation to the Fluvio-marine Crag, and on the Drift of the Eastern Counties. Ann. and Mag. Nat. Hist. 1864, ser. 3, vol. xiii. pp. 185–203.

On the Belgian Equivalents to the Upper and Lower Drift of the Eastern Counties, Ann. and Mag. Nat. Hist. 1864, vol. xiii. pp. 393-405.

The Bridlington Crag. Geol. Mag. 1864, Vol. I. pp. 246-247.

On the Structure of the Red Crag in Suffolk and Essex. Quart. Journ. Geol. Soc. 1864, vol. xx. p. 121; Phil. Mag. 1864, vol. xxvii. p. 155.

On the Formation of the River and other Valleys of the East of England. Phil. Mag. 1864, vol. xxvii. pp. 180-190.

On the Drift of the East of England and its Divisions (1864). Q. J. Geol. Soc. 1865, vol. xxi. pp. 141-142 (abstract); Phil. Mag. 1865, vol. xxix. pp. 240-241.

Remarks in Explanation of the Map of the Upper Tertiaries of the Counties of Norfolk, Suffolk, Essex, Middlesex, Hertford, Cambridge, Huntingdon, and Bedford, with parts of those of Buckingham and Lincoln, and accompanying Sections, for 1865, pp. 24; with Map and Sections (*privately printed.*)

On the Structure of the Thames Valley and of its contained deposits. Geol. Mag. 1866, Vol. III. pp. 57-63, 99-107.

On the Structure of the Valleys of the Blackwater and the Crouch and of East Essex Gravel, and on the Relations of this Gravel to the Denudation of the Weald. Geol. Mag. 1866, Vol. III. pp. 348-354.

On the Relation which the East Essex Gravel bears to the structure of the Weald Valley. Geol. Mag. 1866, Vol. III. pp. 398-406.

On the Structure of the Red Crag, by S. V. Wood, sen., with an Explanation of the Diagram Section by S. V. Wood, jun. Quart. Journ. Geol. Soc. 1866, vol. xxii. pp. 538-552; Phil. Mag. 1866, vol. xxxii. pp. 230-231.

Faults in the Drift at Hitchin. Geol. Mag. 1867, Vol. IV. pp. 37-40.

Age and Position of the Drift-Deposits of the Eastern Counties. Geol. Mag. 1867, Vol. IV. pp. 189-191.

Drift-Deposits of the Eastern Counties. Geol. Mag. 1867, Vol. IV. pp. 375-376.

A Memoir in Explanation of the Structure of the Glacial and Post-Glacial System . . . . over the E., S.E., S., and part of the S.W. of England (1867). Large folio MS. and Maps, in Library Geol. Soc.

Boulder-Clay and Drift of Norfolk and Suffolk, and on the North Side of the Thames Valley. Geol. Mag. 1867, Vol. IV. pp. 479-80.

On the so-called Deposits of the old Estuary of the Yare. Geol. Mag. 1867, Vol. IV. pp. 560-561.

On a Section at Litcham affording Evidence of Land-glaciation during the earlier part of the Glacial Period in England (1866). Quart. Journ. Geol. Soc. 1867, vol. xxiii. pp. 84-87; Phil. Mag. 1867, vol. xxxiii. p. 153.

On the Structure of the Post-Glacial Deposits of the S.E. of England. Quart. Journ. Geol. Soc. 1867, vol. xxiii. pp. 394-417; Phil. Mag. 1867, vol. xxxiv. pp. 402-403. (Corrections in Geol. Mag. Vol. V. pp. 43, 534.)

Reply to W. Boyd-Dawkins, on the Thames Valley Deposits, etc.; and to A. H. Green, on the Ouse Valley at Buckingham. Geol. Mag. 1868, Vol. V. pp. 42-46.

On the Glacial Clay of the Ouse Valley, the Thames Valley, etc. Geol. Mag. 1868, Vol. V. pp. 147-148.

On the Pebble-Beds of Middlesex, Essex, and Herts. Quart. Journ. Geol. Soc. 1868, vol. xxiv. pp. 464-471; Phil. Mag. 1869, vol. xxxvii. pp. 148-149.

On *Astarte excurrens* and *A. modesta.* Ann. and Mag. Nat. Hist. 1870, vol. vi. p. 423.

Observations on the Sequence of the Glacial Beds. Geol. Mag. Vol. VII. 1870, pp. 17-22, 61-68, and Vol. VIII. 1871, pp. 406-412, 477.

The Boulder-Clay of Caithness. Geol. Mag. 1870, Vol. VII. p. 347.

On the Relation of the Boulder-Clay, without Chalk, of the North of England, to the great Chalky Boulder-Clay of the South (1869). Quart. Journ. Geol. Soc. 1870, vol. xxvi. pp. 90-110; Phil. Mag. 1870, vol. xl. pp. 72-73.

On Mr. Croll's Hypothesis of the Formation of the Yorkshire Boulder-Clay. Geol. Mag. 1871, Vol. VIII. p. 92.

On the Evidence afforded by the Detrital Beds without and within the North-Eastern part of the Valley of the Weald as to the Mode and Date of the Denudation of that Valley (1870). Quart. Journ. Geol. Soc. 1871, vol. xxvii. pp. 3-26; Phil. Mag. 1871, vol. xli. p. 319.

On the Assumption of the adult form by the genera *Cypræa* and *Ringicula*, and by certain species of the genus *Astarte.* Ann. and Mag. Nat. Hist. 1871, vol. vii. pp. 171-172.

The Raised Beach on Portsdown Hill. Geol. Mag. 1872, Vol. IX. pp. 92-93.

On the Climate of the Post-Glacial Period. Geol. Mag. 1872, Vol. IX. pp. 153-161.

Reply to Mr. James Geikie's "Correlation of the Scotch and English Glacial Beds." Geol. Mag. 1872, Vol. IX. pp. 171-176, 352-355.

Note on the Shells from the Lower Boulder-Clay of Dawpool. Quart. Journ. Geol. Soc. 1872, vol. xxviii. p. 392.

The Climate Controversy. Geol. Mag. Decade II. Vol. III. 1876, pp. 385-398, 442-451, and Vol. IV. 1877, p. 43.

Physical Geology of East Anglia in the Glacial Epoch. Geol. Mag. 1876, Decade II. Vol. III. pp. 284-286.

American "Surface Geology," and its Relation to British, with some Remarks on the Glacial Conditions in Britain, especially in reference to the "Great Ice Age" of Mr. James Geikie. Geol. Mag. Decade II. Vol. IV. 1877, pp. 481-496, 536-551, and Vol. V. 1878, pp. 13-29, 187-188.

Sub-Glacial Origin of Till. Geol. Mag. Decade II. Vol. V. p. 335.

The Newer Pliocene Period in England (part 1), Comprising the Red and Fluvio-marine and Crag and Glacial Formation. Geol. Mag. Decade II. Vol. VII. pp. 231-235; Quart. Journ. Geol. Soc. 1880, vol. xxxvi. pp. 457-528.

The Glacial Deposits of Cromer. Geol. Mag Decade II. Vol. VII. pp. 189, 190.

Further Remarks on the Origin of the Valley System of the South-Eastern Half of England, prompted by the Result of a Boring near Witham, in Essex. Geol. Mag. 1881, Decade II. Vol. VII. pp. 502-504.

On the Origin of the Loess. Geol. Mag. 1882, pp. 339-343, 411-416.

On the Newer Pliocene Period in England (concluding part). Geol. Mag. Decade II. Vol. IX. 1882, pp. 331-334; Q. J. G. S. xxxviii. 1882, pp. 677-745.

Reply to Mr. Mellard Reade. Geol. Mag. Decade II. Vol. X. p. 240.

On the Cause of the Glacial Period. Geol. Mag. 1883, pp. 293-302.

Chalk-Masses in Cromer Drift. Geol. Mag. 1883, pp. 334, 335, 430.

Further Remarks on the Origin of the Loess. Geol. Mag. 1883, pp. 389-397.

On the Long Meadend Bed. Geol. Mag. 1883, pp. 493-497, 573, 574.

Further Remarks on the Long Meadend Bed. Geol. Mag. 1884, pp. 65-73.

On a New Deposit of Pliocene Age at St. Erth, 15 miles east of Land's End, Cornwall. Geol. Mag. 1884, pp. 572-573; Q.J.G.S. 1885, vol. xli. pp. 65-71.

Wood, Searles Valentine, and Harmer, F. W. On the Glacial and Post-Glacial Structure of Norfolk and Suffolk. Geol. Mag. 1868, Vol. V. pp. 452-456; Brit. Assoc. Report for 1868 (Sect.), pp. 80-83.

On a Peculiar Instance of Intraglacial Erosion near Norwich. Quart. Journ. Geol. Soc. 1869, xxv. pp. 259-260, 445-449; Phil. Mag. 1869, xxxviii. p. 466.

On the Palæontological Aspects of the Middle Glacial Formation of the East of England, and their bearing upon the Age of the Middle Sands of Lancashire. Brit. Assoc. Report for 1870 (Sect). pp. 90-91.

An Outline of the Geology of the Upper Tertiaries of East Anglia, published as an Introduction to part i. 1872, of S. V. Wood's Crag Mollusca, Pal. Soc. Mon. pp. ii.-xxxi. (with Map and Sections).

The Kessingland Freshwater Bed and Weybourne Sand. Geol. Mag. 1877, p. 386.

Observations on Later Tertiary Geology of East Anglia. Q. J. G. S. 1877, pp. 74-119.

Wood, S. V., and Rome, J. L. On the Glacial and Post-Glacial Structure of Lincolnshire and South-East Yorkshire. Phil. Mag. 1867, vol. xxxiv. p. 480; Q. J. G. S. 1868, pp. 2-3, 146-184. [A Map of this area was separately issued.]

ALFRED TYLOR, F.G.S.

Born, 1823. Died, 1884.

Alfred Tylor, F.G.S., of Shepley House, Carshalton, who died on December 31st last, will be remembered as a promoter of technical education at a time when its vital importance was little recognized, and the English manufacturing mind was generally set against it. He was intimately associated with Dr. von Steinbeis, whose energy in this direction did so much to give to the little kingdom of Wurtemburg its industrial prominence in Germany. Mr. Tylor's work, "Education and Manufactures," arising out of his Juryreport on Metal-work at the Exhibition of 1862. was translated into German, and also appeared in Swedish. Mr. Tylor sat for some years on the Council of the Geological Society. His Geological papers relate principally to the flow of rivers as connected with the erosion of valleys and the deposit of gravel-beds; they contain much systematised information, for instance, as to the mechanical action of the Mississippi and the Ganges. It is well known that his study of river-valleys and drift-gravels led him to the hypothesis of a Post-Glacial time of enormous rainfall which he called the "PLUVIAL PERIOD." The term, though not generally acknowledged, has been found of considerable use, to judge from its not unfrequent appearance in many Geological works.

Mr. Tylor's paper "On Changes of the Sea-level and on Denudation" (1853), contains a method of computing the present rate of denudation of the land from the present pluvial and marine action by estimate of the material now being carried out to sea by rivers and removed from cliffs by the sea, and the author contends that there were larger rivers, more rainfall, and greater denudation in former periods.

In his paper "On the Upper and Lower Valley-Gravels of France and England" (1866), the author enunciated the view that what were termed "High" and "Low Valley-Gravels," were of one age, and close to the Historical Period.

His paper in 1868 "On the Amiens Gravel" makes the first definite mention of the "Pluvial Period."

In Mr. Tylor's paper "On the Quaternary Gravels of England," (1869), he gives a calculation to show that the volume of the flood-waters of the Gravel-Period must have been 125 times greater than that at present in the same valleys, and the volume of the rivers 20 times as large as at present.

In his paper "On the Formation of Deltas," etc. (1869), Mr. Tylor suggests a rainfall of 300 inches in the Gravel-Period. He also treats of the law of the Parabolic Curve of River-Valleys, and the lowering of the sea-level 600 feet in the Glacial Period, etc.

In his later years he devoted much time to the consideration of Coloration in Plants and Animals in relation to their structure, as well as to the protective advantages derived by the possession of such colour-markings.

In future years Mr. Tylor will be chiefly remembered not only in the Society of Friends, but in a far wider circle, as one who had the cause of education most earnestly at heart, and still more for the generous and friendly hand which he was at all times ready to extend to help his fellow-men in any way within his power.

The following is a List of his Geological Papers:—

On the Occurrence of Productive Iron Ore in the Eocene Formations of (Hengistbury Head) Hampshire. Quart. Journ. Geol. Soc. 1850, vol. vi. pp. 133–134.

On Changes of the Sea-Level Effected by Existing Physical Causes during Stated Periods of Time. Phil. Mag. 1853, vol. v. pp. 258–281; Silliman's Journ. 1854, vol. xviii. pp. 21–32, 216–229; Quart. Journ. Geol. Soc. 1853, vol. ix. p. 49 (abstract).

On the Footprint of an Iguanodon, lately found at Hastings. Quart. Journ. Geol. Soc. 1862, vol. xviii. pp. 247–253.

On the Discovery of Supposed Human Remains in the Tool-bearing Drift of Moulin-Quignon. Anthropol. Review, 1863, vol. i. pp. 166-168.

On the Interval of Time which has passed between the Formation of the Upper and Lower Valley-Gravels of England and France. Quart. Journ. Geol. Soc. 1866, vol. xxii. pp. 463-468.

On the Amiens Gravel. Quart. Journ. Geol. Soc. 1868, vol. xxiv. pp. 103–125; Geol. Mag. 1867, Vol. IV. p. 105; Silliman's Journ. Science, vol. xlvi. pp. 302-327.

On the Quaternary Gravels of England. Quart. Journ. Geol. Soc. vol. xxiv. 1868, p. 455, and vol. xxv. 1869, pp. 57–100; Geol. Mag. 1868, Vol. V. pp. 338-339.

Discovery of a Pleistocene Freshwater Deposit, with Shells, at Highbury New Park, near Stoke Newington. Geol. Mag. 1868, Vol. V. pp. 391–392.

On the Formation of Deltas, and on the Evidence and Cause of Great Changes of Sea-Level during the Glacial Period. Quart. Journ. Geol. Soc. 1869, vol. xxv. p 9 (abstract). Geol. Mag. 1868, Vol. VI. pp. 576-577.

The same Paper as above brought up to date. Geol. Mag. 1872, Vol. IX. pp. 392–399, 485–500.

On the Action and Formation of Rivers, Lakes, and Streams, with Remarks on Denudation and the Causes of the Great Changes of Climate which have occurred just prior to the Historical Period. Geol. Mag. 1875, Decade II. Vol. XI. pp. 433–476.

Denuding Agencies and Geological Depositions under the Flow of Ice and Water, with the Laws which Regulate these Actions. Quart. Journ. Geol. Soc. 1876, vol. xxxii. pp. 4-9; Geol. Mag. 1876, Decade II. Vol. III. pp. 90-93.

JOHN GWYN JEFFREYS, LL.D., F.R.S., F.L.S., F.G.S.

Born January 18, 1809. Died January 24, 1885.

Dr. J. Gwyn Jeffreys was born at Swansea, January 18th, 1809, and while yet a boy showed considerable taste for natural history, by collecting the insects and shells of South Wales. When only 19 he read a paper at the Linnean Society; and from that date until his decease he has contributed by his writings to our knowledge of the Molluscan fauna of Europe, and the North Atlantic. His most important works are his "British Conchology," and a series of papers in the Proceedings of the Zoological Society, and the Reports of the British Association. At the age of 20 he was elected a Fellow of the Linnean Society, and in 1840 a Fellow of the Royal Society, and an Honorary LL.D. of St. Andrews. He was elected a Fellow of the Geological Society in 1861. He took great interest in the meetings of the British Association, and was Local Treasurer at the 1st meeting at Swansea in 1848, and a Vice-President when the last meeting was held in the same town in 1880. In 1877 he was chosen President of the Biological Section. For many years he filled the office of Treasurer of the Linnean Society, and also of the Geological Society. He took part with Dr. W. B. Carpenter and the late Sir Wyville Thomson in their researches in deep-sea-soundings made by the "Valorous," the "Lightning," and "Porcupine" expeditions. He greatly interested himself in the labours of those French, Belgian, and Italian palæontologists, who devoted themselves to the investigation of the Newer Pliocene deposits of Europe, and many of his own papers have an important bearing upon the Shells of the Glacial Beds in this country. He died at his town-residence (1, The Terrace, Kensington) on Saturday, Jan. 24, 1885, aged 76 years.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. II.

No. IV.—APRIL, 1885.

ORIGINAL ARTICLES.

I.—Oscillations of Level along our South Coast since the Human Period.

By J. Starkie Gardner, F.L.S., F.G.S.

In the latest number of the Quarterly Journal of the Geological Society there is a description by Mr. D. Pigeon, F.G.S., of recent discoveries in the submerged Forest of Torbay. The paper is highly interesting, and records many facts, valuable alike to the geologist and archæologist. But the inferences he draws from them in opposition to Mr. Pengelly, though not altogether unchallenged in the discussion of his paper, were not contradicted as emphatically as they might have been. As I take interest in, and have observed signs of upheaval and depression along our coast-line, and believe that scarcely any part of the coast is at rest, I beg leave to protest against this latest of several attempts to show, that remains of forests, now beneath the sea-level, originally grew at the levels they now occupy. We know that it is possible that forests might grow at a lower level than the sea until a protecting dam gave way and they became overwhelmed; but I would ask whether there is any example of such growing anywhere round the coasts of Great Britain to-day, and whether there is anything to lead to the belief that there were, at the epochs of these submerged forests, any physical conditions that rendered it more probable that forests might have grown below high-water mark along the coasts, then than now. To admit that there were, would admit a change of some kind, presumably of level, which is what I maintain. My own idea is that the physiography, of the south coast at least, is entirely opposed to the growth of forests behind dykes below the sea-level, and that the only probable explanation of their present position is a subsidence of the area on which they grew. This seems so self-evident that I should hardly have thought any other view could have been supported. The conclusion I take most particular exception to is this: "That a coast which has remained stationary for the last 2000 years should have made such active use of the preceding twelve or twenty centuries for the purposes of oscillation, is rather hard of belief." In the first place there is no sort of evidence that the coast was stationary for 2000 years, and in the second, were it so, it would not present any reason to my mind why evidence of the occurrence of oscillations in the 2000 years preceding should be rejected.

Whether Dr. Barham has conclusively established the identity of

Ictis and St. Michael's Mount I do not know; but he has not conclusively established that between B.C. 9, and now, there has been no change of level there. For a good thousand years of the time, Ictis might have been a complete island or a complete peninsula, as we are without records, so long as it afterwards reverted to its original state; or there might have been upheaval of the causeway counterbalanced by the removing power of the waves; or depression of the causeway keeping pace with—concealed—by fresh deposits of sands. The Wash is a long way to go for another example of the stability of coast-land, while as for the opinions of the early English chroniclers, it is not likely they would have observed movements of the coast which scientific observers of the present day have not remarked upon.

Now let us glance along the South Coast only, and we shall find the very reverse of stability. To begin with the Tilbury Docks—down to the very bottom they are blue clay and decayed vegetable layers, the latter so fresh at 40 feet depth that they are still offensive. The subsidence evidenced here can be traced to the mouth of the river. The Swale at Sheppy has, on the other hand, I believe, risen. The Reculvers have risen—the bed of the river which once formed the Isle of Thanet is in places, I believe, above the sea-level. The coast off Richborough has greatly risen since Roman times. I have not observed the chalk cliff-lines since I became interested in the subject, but the Hythe coast must have risen quite 30 feet since Roman times, and the Dungeness shingles are much too high to have been piled in their present position by the sea. The Pevensey flats must also have risen. The sea front of Kent thus seems to be rising. Sussex is partly rising, partly sinking. The sudden irruption of sea and loss of 2700 acres at Selsea indicates subsidence. At Pagham Harbour there is evidence of elevation, first a long continued period of terrestrial surface, and finally subsidence followed by the accumulation of estuarine mud. Recent changes of level are indicated in the Solent by the steep fronts of the mud flats, destitute of weed, which are seen at low-water, proving that a wasting action has set in. The disappearance of mud flats on its shores, described by Fielding in 1753, is evidence of depression during this century, and I have even myself noticed a very great diminution in the mud off Ryde within the last thirty years. Stumps of trees under mud and shingle show a depression of 40 to 50 feet. East of the mouth of Beaulieu river there is a broad expanse of shingle above highest tide, partly overgrown and overlooked by vertical cliffs which the sea never reaches. There are slight evidences of depression in Brading Harbour, amongst others a well has been rendered useless through being covered by the sea at high tide. A well at Portsmouth revealed stumps of trees 29 feet below high-water mark, among them *Lacuna Montaguei* and *Zostera marina* on which it fed, indicating very shallow salt water, above which is 4 feet of blue clay with common living shells. Part of Fort Cumberland, near Portsmouth, stands on a bank of gravel and sand, and owing to some new groins, a fresh direction was given to the tide and a portion of the bank washed away, in the course of which a thick plank with a bolt was discovered, showing that this part of the bank had no great antiquity. An artesian well has also been made to supply Block-house Fort, which for the first 60 feet exhibits nothing but clean shingle, and then a layer of sandy clay full of common oyster-shells, another example of the great changes in the ancient coast and sea-bottom.[1] We may also refer to the well-known tradition that Shanklin Down could not formerly be seen from St. Catherine's Down. There can be no doubt that the river Lym found its outlet to the sea at Freshwater Gate when the Mammoth lived, and that not only has the Solent broken through since then, but an elevation causes the Yar to flow the reverse way, though still occupying the old channel. There is a submerged forest at Bournemouth below low-water mark under the pier, and I have seen at times stumps of trees partly exposed, and large lumps of tangled root and heather partly pyritized, thrown up by the sea on these occasions. The land at Poole, it is well known, is gaining ground on the sea, part of the town now occupying ground where seventy years ago was deep water. In a street a furlong from the sea a stake and post were found buried 6 feet below the present level and evidently forming part of an old embankment. Beds of peat prove that elevation and depressions have taken place in recent times on the shores of Poole Harbour, at the very edge and even in the water itself. Mr. Clarke mentions in his paper, in the Quarterly Journal of the Geological Society, that the sand dunes advanced half a mile between the years 1785 and 1829, and that the new series on the south side were formed in five years. Bourne Valley contains beds of peat ten to twenty feet thick, with huge trees of oak, hazel, beech, etc., none of which would have grown in an undrained swamp. A Roman *via* now terminates at half a mile from the north head of Hole's Bay, in what is now a marsh and extensive peat bog, having probably originally terminated in a landing-place. Such examples on both sides of the Channel are endless, and are referred to in scores of works; but I will pass on to Devonshire itself.

The ancient alluvium of the Dart shows that it formerly flowed at a much greater elevation above the sea. Pengelly records the remains of boring mollusca 200 feet above the present sea-level at Kent's Hole. Could anything in fact be more eloquent of changes in level and denudation, since the period of man, than this Kent's Hole, perched on a hill, and preserving to us a fragment of a water-course where no water could possibly flow now? Mr. J. A. Colenso communicated to the Royal Cornwall Geological Society the occurrence under deposits of gravel and mud, of both marine and freshwater deposition, of trunks of trees *in situ*, 34 feet below lowest spring-tide low-water mark, and 12 feet higher, occurred a piece of wood worked by man.

At Pentuan human remains were found 40 feet below the surface and 34 feet below high-water; at Carnon they were found at a depth of 58 feet and 64 feet below high-water; from 40 feet a wooden shovel and deer-horn pick were disinterred. Sir H. de la Beche thought these discoveries showed that a considerable change had taken place in the relative levels of sea and land since man inhabited Cornwall. The submerged forests show a sinking to the extent of 70 feet. Much information regarding the changes of level in Cornwall is included in Mr. Ussher's Post-Tertiary Geology of that County, 1879, and he concludes that there has been so much subsidence since the Glacial period that only what was the watershed now remains. Mr. Pigeon, in the very article I am questioning, admits that there have been enormous encroachments of the sea in Torbay since maps were published; but how could these occur, without subsidence? Torbay is a deep indentation of the coast, of a form that suggests that detritus would not be rapidly removed out to sea by currents, and so fast a destruction of the coast must have led to the formation of shoals were there no depression, in progress. Mr. Blanford indeed pertinently questioned how smelting hearths could have been situated 10 feet below high-water mark. I think I have pointed to sufficient material, hastily looked up, to prove that while Mr. Pigeon's facts are valuable, the conclusion he has drawn from them is based on a misconception of the amount of change our coasts have undergone since the human period. The difficulty is not to find a coast-line that does present evidence of recent changes of level, but any that does not. When we find so guarded an observer as Dr. John Evans expressing the opinion that the whole of Southampton Water has been excavated since the deposition of the Hill Head Gravel, and stating that in the gravel at Southampton Common, water-worn flint implements are met with at an elevation of 180 feet above high-water mark, and at 130 feet at Bournemouth, and that since Britain was inhabited by man a tract of country fifteen miles long and five or six miles broad has been swept into the sea, and the Isle of Wight severed from the mainland, we need hardly make a difficulty in admitting that the Torbay Forest has subsided even 40 feet. The late Mr. Godwin-Austen in his celebrated paper proving the English Channel to be due to depression and not excavation, made some such remarks as these, with which I cannot do better than conclude this protest: "That the whole area of the English Channel had at one time a higher level, is directly proved by the numerous instances along its shores where old forest ground passes beneath the present sea-bed; these forests include elm, oak, chestnut, hazel, and especially *Pinus sylvestris*, none of which have their usual habitat along the sea-border. No wooded tracts came down to the present coasts of the Channel, nor even single trees of any bulk, yet in many instances the trees of these submerged lands had attained considerable magnitude."

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[1] Report of Brit. Assoc. for 1848, Trans. Sections, p. 72. See also Quart. Journ. Geol. Soc. 1847, p. 249, 1870, p. 84.

II.—INTERMITTENT STREAMS IN BERKSHIRE.

By Professor T. RUPERT JONES, F.R.S., F.G.S., &c., &c.

THE Lambourn river, in Berkshire, which rises from springs in the Chalk hills between Up-Lambourn and Chipping-Lambourn, and receives other springs lower down, has been dry for about six miles between Lambourn and Shefford this winter; and the Winterbourn, a smaller stream, which rises close to the Ford, at Chapel Copse on the Leckhampstead estate, near Chieveley, has also been dry from its source to near Bagnor (nearly four miles), where it joins the Lambourn.

The Lambourn was dry, as above, in 1854 and 1871, and formerly it had the credit of always having a smaller stream in winter than in summer, and thus being less lavish of its water when all the other rivers were flooding the Kennet. Mr. Walter Money, F.S.A., of Newbury, states that it gets dry usually about Michaelmas, and runs again about February, when abundant trout, good in colour and flavour, go up the stream, which keeps full in the summer. In the "Transactions Newbury District Field Club," vol. i. 1872, p. 147, Mr. Hippisley remarked that the Lambourn was dry at its source on November 15th, 1870, and that it began to run again on Feb. 24th, 1871, and on the 6th April, it flowed over the weir of the fish-pond. In the volume referred to, a photograph illustrates this prettily wooded "Source of the Lambourn."

The Winterbourn is usually deficient; but after the wet years of 1879, 1880, 1881, and 1882, the brook rose and ran freely (according to Mr. W. Fisher, formerly of Winterbourn). After the very wet year of 1879 it was running strong in December, though the rise is usually expected in January or February; and, if not by that time, it does not appear at all. It flows (he states) about four times in seven years; and usually dwindles away by the end of July or in August.

Mr. Horton, of East Ilsley, Berks, states that the little river Pang, ordinarily having its rise in the Chalk near Hampstead-Norris, in very wet winters begins at Hodcot, near West Ilsley (four miles to the N.W.), and forms (as it did in 1882–3) a chain of ponds in its course through East Ilsley, where it comes once in five or six years. These head-waters of the Pang, when running through the fields between Ilsley and Compton, slacken in April, and are lost for about 100 yards in fissures of the Chalk underground. Mr. W. Money adds that, in his "History and Antiquities of the Hundred of Compton," Mr. Hewett mentioned the springs near Ilsley as having been particularly high in 1799, 1809, 1819, and 1839. Another statement, referred to, is that they burst out of the Chalk about once in six years, and "never till the Thames has been thrice flooded." Dr. Plot, in his "Natural History of Oxfordshire, etc.," long ago noticed that when the springs failed, the crops were unusually good. Mr. W. Money says that this was the case in 1884.

The subject of "intermittent streams" has been treated of by Dr. John Evans, F.R.S., etc., when describing the Bourn at Berkhampstead, in the "Transactions of the Hertfordshire Natural-History Society," vol. ii. (1884), pages lvii–lix; and Mr. W. Whitaker has described the Croydon example in the "Memoirs of the Geological Survey," etc., vol. iv. (1872), pages 391, 392; and it is known, from general observation and from careful experiments on the relative percolation of water through different soils and rocks, including chalk, that all streams are dependent upon the rainfall. The water sinks more or less perfectly and rapidly into the Chalk hills, until it is stopped by an impervious layer of clay, or other dense material, such as the Chalk-marl, or, if this be fissured, the Gault below it. The Chalk is some few hundreds of feet thick, and becomes highly saturated (in its minute cracks and larger rifts and fissures) with the rain-water; and this reaches upwards to a plane coinciding roughly with some of the hill contours, and also sloping down to the levels at which this underground water is discharged in the valleys intersecting the country. These, when cut down as low as, or below, the line or plane of saturation, may be said to "tap" the subterranean store of water; and they have continuous streams, from weak places in the Chalk, as long as the rain-water saturates the Chalk up to the level of the old springs, which rarely fail. After a larger supply of water than usual (perhaps months after a rainy season, or perhaps soon after a heavy rain, according to the amount of rain and the rate of percolation), the subterranean store of water will rise above the previous average level; and, reaching some crack or opening in the surface of the Chalk, it will leak out, or run freely as a spring and stream, until the underground water of the hills is reduced to its ordinary level. Such occasional and temporary outpourings are known as Bourns, Winterbourns, Nailbourns, Woe-waters, etc.

With respect to the empty condition of the Lambourn and Winterbourn in Berkshire, evidently the "plane of saturation" in the neighbouring hills has been reduced to a very low level, below the feeding cracks of the usual springs. If the country has been fortunate in getting plenty of rain of late, it will have full streams again in due time. Mr. Horton says that the *plane of saturation* is now reduced below the average level of the water in the wells in the neighbourhood of East Ilsley, and that the scarcity of water has been unprecedented for many years.

Formerly it was supposed that the water accumulated in one or more large reservoirs or cavities, connected by curved fissures with the surface; and that, when the water had filled both the cavities and the fissures up to and above the highest level of an upward curved pipe-like communication with the outside, the water would begin its outflow, and continue until the lowest practical level was arrived at by this *syphon* action. This hypothetical explanation of the phenomenon of a winterbourn is now superseded, and thought to be quite unnecessary in view of the facts above mentioned, as to the plane of saturation, and its intersection by valleys, with fissures tapping it at ordinary levels, and its occasional uprise to higher cracks, which give vent to the surplus water at uncertain periods, either shortly or long after heavy rains, as the case may be.—"*Newbury Weekly News*," January and February, 1885.

III.—CONTRIBUTIONS TO THE PALÆONTOLOGY OF THE YORKSHIRE OOLITES.

By WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S.

(Continued from Decade III. Vol. II. p. 129.)

(PLATE IV.)

80.—PLEUROTOMARIA DEPRESSA, Phillips, 1829. Plate IV. Figs. 1, 2, 2*a*.

1829, 1835. *Cirrus depressus*, Phillips, G. Y. p. 112, plate vi. fig. 12. K.R.
1849. *Pleurotomaria depressa*, D'Orb. Prod. i. p. 333. Et. Cal.
1854. ———— *depressa*, Phil. Morr. Cat. p. 271.
1859. *Pleurotomaria striata*, Bean, MS. Leckenby, Q.J.G.S. p. 12, pl. iii. fig. 2.
1860. *Pleurotomaria Montreuilensis*, H. and D. Foss. Mont. Bellay, p. 68, pl. v. fig. 3.
1860. *Pleurotomaria striata*, Leck. *Op. cit.* pl. v. fig. 4.
1875 { *Pleurotomaria depressa*, Phil. / *Pleurotomaria striata*, Leck. } As distinct species, Phillips, G. Y. 3rd ed. p. 250.

Bibliography, etc.—Phillips's type was evidently a cast from the Kelloway Rock, of Hackness, near Scarborough. I have not been able to identify the original, which was supplied by Bean. The figure, however, plainly shows it to have been a cast of a good-sized discoidal shell, and there are specimens now in the Bean Collection at the British Museum not unlike it.

On the other hand, Bean's *Cirrus striatus*, described and figured by Mr. Leckenby (Fig. 2 of our Plate), having been preserved in the hard grit of the Kelloway Rock, exhibits what was probably a faithful outline of the original shell. At first sight there would seem to exist no connexion whatever between the two; but when we examine such a specimen as the one I have described but not figured (see second description), the relationship between the cast and the shell becomes more easy to understand. It is to be regretted that the rule of priority should be allowed to extend to species founded on casts, especially when there is not a word of description. But Mr. Leckenby himself appears to have acquiesced in the adoption of the rule, since we find the type of *Pl. striata* is placed in a tray with two other specimens in the more usual condition, the tray being labelled *Pl. depressa*, Phil.

If we wish to see what a well-developed and well-preserved shell of *Pl. depressa* is like, we may turn to Hébert and Deslongchamps figure of *Pl. striata*, Leck., and I think there can be little doubt that *Pl. Montrueilensis* of the same authors is so near that it may well be placed in the same category.

Descriptions.—Specimen from a hard grit of the Kelloway Rock (zone 5), Castle Hill, Scarborough. Leckenby Collection. TYPE of *Pl. striata* REFIGURED. Fig. 2.

The following is Mr. Leckenby's description :—"Shell depressed: whorls four, tabulated; keel slightly prominent, transversely ridged, and crossed by numerous very fine oblique irregularly undulating, raised lines, which pass uninterruptedly over the keel." Our artist

has succeeded in depicting this shell with great skill and fidelity. It must not be supposed that the spiral ornamentation is absent, but it is overpowered by the radial ornamentation. The keel is slightly imbricated, and doubtless contained the slit-band, though we must partly rely upon inference in arriving at this conclusion.

Another specimen.—From the soft reddish marly grit with grey ova of the Kelloway Rock (zone 5), Scarborough or Hackness. Bean Collection, British Museum. This one represents the more ordinary condition of the fossil, and would at once be recognized as *Pl. depressa*, Phil. Not figured.

The four inner (posterior) whorls greatly resemble those of the preceding specimen; the ornamentation is coarser, and the spiral system more obvious. The development of a discoidal body-whorl, which nearly doubles the width of the shell, constitutes the chief difference. Since this body-whorl is in a "half cast" condition, it is difficult to say how far the angular shape of the whorls of the spire is retained; but judging from some remains of the outer shell, it would seem as though the smooth outline of the body-whorl (see figure in G. Y. pl. vi. 12), does not in any way represent the external form originally possessed by the specimen. Umbilicus wide and deep.

Another specimen.—From the Oxford Clay (zone 6), Scarborough. York Museum. Fig. 1.

This has been compressed till it is not much thicker than a crown piece; but the fineness of the ornamentation, and the general aspect of the shell serve to connect it with Leckenby's *Pl. striata*. An inspection of the figure will do more in this case than any further attempt at description.

Relations and Distribution.—Although this species, in common with the one last described (*Pl. granulata*, Lycett, non Sow.), is a member of the *granulata*-group, it differs from the general average of Inferior Oolite fossils referable to Sowerby's species in a direction almost opposite to that of Lycett. Instead of having a higher spire than the true *Pl. granulata*, the shell is extremely depressed, the whorls being very angular and tabulate. It is considerably excavated, and thus agrees better with the generality of Inferior Oolite specimens belonging to the *granulata*-group. On the other hand, the ornamentation is much finer, and this is so marked in Leckenby's *Pl. striata*, that subsequently his species may come to be regarded as a variety of *Pl. depressa*.

Nothing can be more difficult than to trace a particular member of the *granulata*-group through a cloud of synonyms. The Inferior Oolite fossil to which *Pl. depressa* bears the most resemblance is *Pl. palemon*, D'Orb., though more in shape than in ornamentation. Quoted by Brauns under the name of *Pl. granulata*, Sow., from the equivalents of the Cornbrash and Kelloway Rock of N.W. Germany. In Yorkshire *Pl. depressa* is only known from the Kelloway Rock and Lower "Oxford Clay," in the latter of which it is rare.

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1860. *Pleurotomaria Montreuilensis*, H. and D. Foss. Mont. Bellay, p. 68, pl. v. fig. 3.
1860. *Pleurotomaria striata*, Leck. *Op. cit.* pl. v. fig. 4.
1875 { *Pleurotomaria depressa*, Phil. } As distinct species, Phillips, G. Y. 3rd ed.
{ *Pleurotomaria striata*, Leck. } p. 250.

Bibliography, etc.—Phillips's type was evidently a cast from the Kelloway Rock, of Hackness, near Scarborough. I have not been able to identify the original, which was supplied by Bean. The figure, however, plainly shows it to have been a cast of a good-sized discoidal shell, and there are specimens now in the Bean Collection at the British Museum not unlike it.

On the other hand, Bean's *Cirrus striatus*, described and figured by Mr. Leckenby (Fig. 2 of our Plate), having been preserved in the hard grit of the Kelloway Rock, exhibits what was probably a faithful outline of the original shell. At first sight there would seem to exist no connexion whatever between the two; but when we examine such a specimen as the one I have described but not figured (see second description), the relationship between the cast and the shell becomes more easy to understand. It is to be regretted that the rule of priority should be allowed to extend to species founded on casts, especially when there is not a word of description. But Mr. Leckenby himself appears to have acquiesced in the adoption of the rule, since we find the type of *Pl. striata* is placed in a tray with two other specimens in the more usual condition, the tray being labelled *Pl. depressa*, Phil.

If we wish to see what a well-developed and well-preserved shell of *Pl. depressa* is like, we may turn to Hébert and Deslongchamps figure of *Pl. striata*, Leck., and I think there can be little doubt that *Pl. Montrueilensis* of the same authors is so near that it may well be placed in the same category.

Descriptions.—Specimen from a hard grit of the Kelloway Rock (zone 5), Castle Hill, Scarborough. Leckenby Collection. TYPE of *Pl. striata* REFIGURED. Fig. 2.

The following is Mr. Leckenby's description:—"Shell depressed: whorls four, tabulated; keel slightly prominent, transversely ridged, and crossed by numerous very fine oblique irregularly undulating, raised lines, which pass uninterruptedly over the keel." Our artist

81.—PLEUROTOMARIA GUTTATA, Phillips, 1829. Plate IV. Figs. 3, 3*a*, and 4.

1829, 1835. *Trochus guttatus*, Phillips, G. Y. p. 112, pl. vi. fig. 14. K.R.
1849. *Pleurotomaria guttata*, D'Orbigny. Prod. 1. p. 333. Et. Cal.
1854. *Trochus guttatus*, Phil. Morris, Cat. p. 281.
1859. *Pleurotomaria arenosa*, Leckenby, Q.J.G.S. 1859, p. 12, pl. 3, fig. 1.
1875. *Pl. guttata*, Phil. } as distinct species. Phillips, G. Y. 3rd ed. p. 259.
Pl. arenosa, Leck. }

Compare also—

Pleurotomaria cincta (Münst), D'Orb., T. J. p. 560, pl. 420.
,, *galathea*, D'Orbigny, T. J. p. 566, pl. 423, figs 1–4.
,, *clathrata*, Münst. Goldf. Pet. 3, p. 71, plate 186, fig. 8.

Bibliography, etc.—I have not seen the type of *Trochus guttatus*, which belonged to Williamson, and should be in the Scarborough Museum. Phillips's figure is fairly characteristic, and shows the crenulated girdle very clearly. Our Figure 4 represents a fossil in a somewhat similar condition. D'Orbigny recognized Phillips's species as a *Pleurotomaria*, though Morris did not seem to have been satisfied on this point, probably because of the apparent want of the band of the sinus (slit-band). We cannot wonder that, when Mr. Leckenby obtained such a beautiful fragment as is depicted in our Figure 3, he should have fancied he had found a new species (*Pl. arenosa*).

The difference between *Pl. guttata* and *Pl. arenosa* seems to have been accepted by Phillips without question in his last edition. Yet it is evident that Mr. Leckenby finally regarded them as synonymous. The following note in the Woodwardian Museum testifies to this—"Under the title *P. arenosa* I have unfortunately described in my paper on the Kelloway Rock in the Geol. Journ. Feb. 1859, a specimen then in Bean's Collection, now in the British Museum, which on a subsequent examination of Phillips's *Trochus guttatus* in the Scarborough Museum, I find to be only a more perfect condition of the latter shell.

"Phillips's figure is that of partial cast, the only portion of the shell preserved being a thickened band at the suture."

Descriptions.—Specimen from the Kelloway Rock (zone 5), Scarborough. Leckenby Collection. Fig. 4.

Approximate	Height..............................	30 millimètres.
	Width	40 ,,
	Mean spiral angle	89°.
	Ratio of body-whorl to entire height ..	50 : 100.

Shell conical, trochoid, much wider than high, moderately (?) umbilicated. The angle of the spire is slightly concave, so that between the opening of the spiral angle and the mean spiral angle there is a difference of some degrees. Number of whorls about 8, tapering to a sharp apex: the whorls are nearly flat, and their inclination about the same as the mean angle of the spire.

The ornaments consist of tolerably close spiral lines, which are decussated by axial lines, and more so in the posterior than in the anterior region. The base of each whorl is distinguished by a handsome crenulated girdle: just above this lies the band of the sinus (slit-band), which is narrow and projects slightly from the general level of the whorl. Cast of the body-whorl showing very faint traces of a carina. Other indications wanting.

Another specimen.—From the Kelloway Rock (zone 5), Scarborough. Bean Collection, British Museum. TYPE of *Pl. arenosa* REFIGURED. Fig. 3.

Approximate value of the spiral angle .... 92°.

Though broken and imbedded in matrix, portions of the shell are exquisitely preserved in spar tinged externally with brown oxide of iron. Owing to the prominence of the basal girdle, the shell is zoned rather than turrited. Posterior ¾ths of each whorl flat and sloping, remainder occupied by the girdle.

The ornaments consist of a reticulate system which occupies the posterior half of the whorl: in the penult this is very regular and slightly tuberculated at the nodes: in the centre of the space between this reticulate system and the girdle lies the band of the sinus, which is narrow and salient, but less salient than the girdle, which consists of four crenulated spirals welded together (see Fig. 3*a*). The cast of the last whorl visible is smooth, yet slightly angular at the turn. Other indications wanting.

Relations and Distribution.—The reticulate structure of the posterior portion of each whorl, the position of the somewhat narrow and yet prominent slit-band, and the crenulated belt at the base are characters of a group of *Pleurotomariæ*, which has many members. There are shells in the Inferior Oolite of Sherborne, which even show a connecting link between *Pl. guttata* and *P. granulata*, Sow., and it may well happen that from such the Oxfordian species now under consideration has been modified. The varieties of *Pleurotomaria* are so infinite wherever the genus is well represented, that authors have hardly known where to stop in naming specific forms. Hence it is possible that no absolute identification with continental fossils can be established in this case.

Pl. clathrata, Münst., from the "Jurakalke" of Pappenheim, has a tolerably close resemblance to the conditions represented by *Pl. arenosa*, but Goldfuss's figure is an enlargement. Mr. Leckenby considered that the species described by him was closely allied to *Pl. galathea*, D'Orb., also an Oxfordian species. In this case the spiral angle is about the same, yet in other respects there are differences of some importance. On the whole I am disposed to regard *Pl. cincta* (Münst.), D'Orb., as being the nearest to *Pl. guttata*, if not identical. The slightly concave angle of the spire in both is very similar. D'Orbigny says that *Pl. cincta* is special to the Oxfordian, occurring both in France and Germany. Whether his species is really the same as *Trochus cinctus*, Münst., is another question.

Pleurotomaria guttata is confined, in Yorkshire, to the Kelloway Rock, where it is rather rare.

82.—PLEUROTOMARIA ANGLICA, Sowerby, 1816. Pl. IV. Fig. 5.

1816. *Trochus similus* (sic), Sowerby, Min. Conch. pl. 142; *T. anglica* in Index to vol. ii.

1848. *Pleurotomaria undosa*, Deslongch., Mém. Soc. Linn. Norm. vol. viii. p. 77, pl. 12, fig. 2. Upper Lias.
1849. *Pleurotomaria anglica*, D'Orbigny, Prod. i. p. 214. Et. Siném.
1854. *Pleurotomaria anglica*, Sow., Morr. Cat. p. 271. Lias; Yorkshire, Somerset.
1876. *Pleurotomaria undosa*, Sow., Tate and Blake, p. 339, pl. 9, fig. 1. Mid. Lias.

Bibliography, etc.—Since this is essentially a Liassic rather than an Oolitic species, I feel scarcely justified in criticizing the literature. The Dogger fossil is not unlike Sowerby's type; but if there is a difference, it leans perhaps more to the *undosa* variety. Sowerby says that Lister found *Pl. anglica* at Bugthorpe, in Yorkshire, and figured it in his Conchology.

Description.—Specimen from the Dogger (zone 1), Peak (Blue Wyke). York Museum.

Approximate	Height	60 millimètres.
	Width	56 ,,
	Spiral angle	75°.

Shell of large habit, trochiform, strongly turrited: height and width nearly equal. Whorls about 8, increasing by steps within a tolerably regular angle. The carina is situated towards the upper part: it is coarsely tuberculated, the tubercles being depressed and drawn out spirally: the entire shell seems to have been pervaded by a system of fine spiral lines.

The band of the sinus is very conspicuous in the body-whorl, and is situated rather less than half-way between the carina and the margin of the base. It constitutes a slight prominence, and seems to show the "three central striæ" mentioned by Sowerby in his diagnosis.

Relations and Distribution.—Owing to the imperfect condition of the shell, an absolutely correct identification of the Dogger fossil with this or that member of the *anglica*-group is almost impossible. It comes very near *Pl. araneosa*, Desl. (cf. D'Orb. T.J. p. 416, pl. 352, figs. 5–9), a Middle Lias species, but in that one the band of the sinus is in a slight depression, whereas in our shell it occupies a slight prominence. The large *Pleurotomariæ* of the French Bajocian are all different from this one, and so are those of Dorset-Somerset as far as my knowledge extends.

The highly ferruginous matrix and other indications convince me that the specimen figured belongs to the Dogger proper, and not to the Dogger Sands. But a specimen was found lately by Mr. Walter Keeping, which I understood him to say had been obtained from the sands that carry the Dogger. There are three specimens in the York Museum. I know of none others from this horizon.[*]

[*] 1. There is nothing absolutely exceptional in the reappearance of Liassic forms in the Inferior Oolite. We have a remarkable instance of this in the presence of large specimens of *Ammonites fimbriatus* in the *Humphresianus*-bed at Oborne, near Sherborne. In that case there can be no doubt that a few individuals of *Am. fimbriatus* lived to witness the reign of the coronati.

2. There are two species of *Pleurotomaria*, in addition to the four already detailed by me, included in the list of the "Geology of Yorkshire" (3rd ed. p. 259), of whose title to be regarded as Yorkshire fossils I can find no evidence. These are:
Pleurotomaria bicarinata, Sow., t. 221. Calc. Grit, Gristhorpe.
Pleurotomaria cingulata, Phil. Calc. Grit, Scarborough.

has succeeded in depicting this shell with great skill and fidelity. It must not be supposed that the spiral ornamentation is absent, but it is overpowered by the radial ornamentation. The keel is slightly imbricated, and doubtless contained the slit-band, though we must partly rely upon inference in arriving at this conclusion.

Another specimen.—From the soft reddish marly grit with grey ova of the Kelloway Rock (zone 5), Scarborough or Hackness. Bean Collection, British Museum. This one represents the more ordinary condition of the fossil, and would at once be recognized as *Pl. depressa*, Phil. Not figured.

The four inner (posterior) whorls greatly resemble those of the preceding specimen; the ornamentation is coarser, and the spiral system more obvious. The development of a discoidal body-whorl, which nearly doubles the width of the shell, constitutes the chief difference. Since this body-whorl is in a "half cast" condition, it is difficult to say how far the angular shape of the whorls of the spire is retained; but judging from some remains of the outer shell, it would seem as though the smooth outline of the body-whorl (see figure in G. Y. pl. vi. 12), does not in any way represent the external form originally possessed by the specimen. Umbilicus wide and deep.

Another specimen.—From the Oxford Clay (zone 6), Scarborough. York Museum. Fig. 1.

This has been compressed till it is not much thicker than a crown piece; but the fineness of the ornamentation, and the general aspect of the shell serve to connect it with Leckenby's *Pl. striata.* An inspection of the figure will do more in this case than any further attempt at description.

Relations and Distribution.—Although this species, in common with the one last described (*Pl. granulata*, Lycett, non Sow.), is a member of the *granulata*-group, it differs from the general average of Inferior Oolite fossils referable to Sowerby's species in a direction almost opposite to that of Lycett. Instead of having a higher spire than the true *Pl. granulata*, the shell is extremely depressed, the whorls being very angular and tabulate. It is considerably excavated, and thus agrees better with the generality of Inferior Oolite specimens belonging to the *granulata*-group. On the other hand, the ornamentation is much finer, and this is so marked in Leckenby's *Pl. striata*, that subsequently his species may come to be regarded as a variety of *Pl. depressa.*

Nothing can be more difficult than to trace a particular member of the *granulata*-group through a cloud of synonyms. The Inferior Oolite fossil to which *Pl. depressa* bears the most resemblance is *Pl. palemon*, D'Orb., though more in shape than in ornamentation. Quoted by Brauns under the name of *Pl. granulata*, Sow., from the equivalents of the Cornbrash and Kelloway Rock of N.W. Germany. In Yorkshire *Pl. depressa* is only known from the Kelloway Rock and Lower "Oxford Clay," in the latter of which it is rare.

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on the relative percolation of water through different soils and rocks, including chalk, that all streams are dependent upon the rainfall. The water sinks more or less perfectly and rapidly into the Chalk hills, until it is stopped by an impervious layer of clay, or other dense material, such as the Chalk-marl, or, if this be fissured, the Gault below it. The Chalk is some few hundreds of feet thick, and becomes highly saturated (in its minute cracks and larger rifts and fissures) with the rain-water; and this reaches upwards to a plane coinciding roughly with some of the hill contours, and also sloping down to the levels at which this underground water is discharged in the valleys intersecting the country. These, when cut down as low as, or below, the line or plane of saturation, may be said to "tap" the subterranean store of water; and they have continuous streams, from weak places in the Chalk, as long as the rain-water saturates the Chalk up to the level of the old springs, which rarely fail. After a larger supply of water than usual (perhaps months after a rainy season, or perhaps soon after a heavy rain, according to the amount of rain and the rate of percolation), the subterranean store of water will rise above the previous average level; and, reaching some crack or opening in the surface of the Chalk, it will leak out, or run freely as a spring and stream, until the underground water of the hills is reduced to its ordinary level. Such occasional and temporary outpourings are known as Bourns, Winterbourns, Nailbourns, Woe-waters, etc.

With respect to the empty condition of the Lambourn and Winterbourn in Berkshire, evidently the "plane of saturation" in the neighbouring hills has been reduced to a very low level, below the feeding cracks of the usual springs. If the country has been fortunate in getting plenty of rain of late, it will have full streams again in due time. Mr. Horton says that the *plane of saturation* is now reduced below the average level of the water in the wells in the neighbourhood of East Ilsley, and that the scarcity of water has been unprecedented for many years.

Formerly it was supposed that the water accumulated in one or more large reservoirs or cavities, connected by curved fissures with the surface; and that, when the water had filled both the cavities and the fissures up to and above the highest level of an upward curved pipe-like communication with the outside, the water would begin its outflow, and continue until the lowest practical level was arrived at by this *syphon* action. This hypothetical explanation of the phenomenon of a winterbourn is now superseded, and thought to be quite unnecessary in view of the facts above mentioned, as to the plane of saturation, and its intersection by valleys, with fissures tapping it at ordinary levels, and its occasional uprise to higher cracks, which give vent to the surplus water at uncertain periods, either shortly or long after heavy rains, as the case may be.—"*Newbury Weekly News,*" January and February, 1885.

III.—CONTRIBUTIONS TO THE PALÆONTOLOGY OF THE YORKSHIRE OOLITES.

By WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S.

(Continued from Decade III. Vol. II. p. 129.)

(PLATE IV.)

80.—PLEUROTOMARIA DEPRESSA, Phillips, 1829. Plate IV. Figs. 1, 2, 2*a*.

1829, 1835. *Cirrus depressus*, Phillips, G. Y. p. 112, plate vi. fig. 12. K.R.
1849. *Pleurotomaria depressa*, D'Orb. Prod. i. p. 333. Et. Cal.
1854. ———— *depressa*, Phil. Morr. Cat. p. 271.
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On the other hand, Bean's *Cirrus striatus*, described and figured by Mr. Leckenby (Fig. 2 of our Plate), having been preserved in the hard grit of the Kelloway Rock, exhibits what was probably a faithful outline of the original shell. At first sight there would seem to exist no connexion whatever between the two; but when we examine such a specimen as the one I have described but not figured (see second description), the relationship between the cast and the shell becomes more easy to understand. It is to be regretted that the rule of priority should be allowed to extend to species founded on casts, especially when there is not a word of description. But Mr. Leckenby himself appears to have acquiesced in the adoption of the rule, since we find the type of *Pl. striata* is placed in a tray with two other specimens in the more usual condition, the tray being labelled *Pl. depressa*, Phil.

If we wish to see what a well-developed and well-preserved shell of *Pl. depressa* is like, we may turn to Hébert and Deslongchamps figure of *Pl. striata*, Leck., and I think there can be little doubt that *Pl. Montrueilensis* of the same authors is so near that it may well be placed in the same category.

Descriptions.—Specimen from a hard grit of the Kelloway Rock (zone 5), Castle Hill, Scarborough. Leckenby Collection. TYPE of *Pl. striata* REFIGURED. Fig. 2.

The following is Mr. Leckenby's description:—"Shell depressed: whorls four, tabulated; keel slightly prominent, transversely ridged, and crossed by numerous very fine oblique irregularly undulating, raised lines, which pass uninterruptedly over the keel." Our artist

has succeeded in depicting this shell with great skill and fidelity. It must not be supposed that the spiral ornamentation is absent, but it is overpowered by the radial ornamentation. The keel is slightly imbricated, and doubtless contained the slit-band, though we must partly rely upon inference in arriving at this conclusion.

Another specimen.—From the soft reddish marly grit with grey ova of the Kelloway Rock (zone 5), Scarborough or Hackness. Bean Collection, British Museum. This one represents the more ordinary condition of the fossil, and would at once be recognized as *Pl. depressa*, Phil. Not figured.

The four inner (posterior) whorls greatly resemble those of the preceding specimen; the ornamentation is coarser, and the spiral system more obvious. The development of a discoidal body-whorl, which nearly doubles the width of the shell, constitutes the chief difference. Since this body-whorl is in a "half cast" condition, it is difficult to say how far the angular shape of the whorls of the spire is retained; but judging from some remains of the outer shell, it would seem as though the smooth outline of the body-whorl (see figure in G. Y. pl. vi. 12), does not in any way represent the external form originally possessed by the specimen. Umbilicus wide and deep.

Another specimen.—From the Oxford Clay (zone 6), Scarborough. York Museum. Fig. 1.

This has been compressed till it is not much thicker than a crown piece; but the fineness of the ornamentation, and the general aspect of the shell serve to connect it with Leckenby's *Pl. striata.* An inspection of the figure will do more in this case than any further attempt at description.

Relations and Distribution.—Although this species, in common with the one last described (*Pl. granulata*, Lycett, non Sow.), is a member of the *granulata*-group, it differs from the general average of Inferior Oolite fossils referable to Sowerby's species in a direction almost opposite to that of Lycett. Instead of having a higher spire than the true *Pl. granulata*, the shell is extremely depressed, the whorls being very angular and tabulate. It is considerably excavated, and thus agrees better with the generality of Inferior Oolite specimens belonging to the *granulata*-group. On the other hand, the ornamentation is much finer, and this is so marked in Leckenby's *Pl. striata*, that subsequently his species may come to be regarded as a variety of *Pl. depressa.*

Nothing can be more difficult than to trace a particular member of the *granulata*-group through a cloud of synonyms. The Inferior Oolite fossil to which *Pl. depressa* bears the most resemblance is *Pl. palemon*, D'Orb., though more in shape than in ornamentation. Quoted by Brauns under the name of *Pl. granulata*, Sow., from the equivalents of the Cornbrash and Kelloway Rock of N.W. Germany. In Yorkshire *Pl. depressa* is only known from the Kelloway Rock and Lower "Oxford Clay," in the latter of which it is rare.

Patella graphica is founded on a single specimen. Should a common specific name be required for this section of *P. rugosa*, it is evident that *P. tenuistriata*, Deslong., must take precedence.

EXPLANATION OF PLATE IV.

Fig. 1. *Pleurotomaria depressa*, Phil. Oxford Clay, Scarborough. York Museum. Apical view. Flattened specimen.
„ 2. *Pleurotomaria depressa*, Phil. Kelloway Rock, Scarborough. Leckenby Collection. TYPE of *Pl. striata*, Leckenby, REFIGURED. Apical view. 2*a*. portion enlarged.
„ 3. *Pleurotomaria guttata*, Phil. Kelloway Rock, Scarborough. Bean Collection, British Museum. TYPE of *Pl. arenosa*, Leckenby, REFIGURED. 3*a*. portion enlarged.
„ 4. *Pleurotomaria guttata*, Phil. Kelloway Rock, Scarborough. Leckenby Collection. Back view.
„ 5. *Pleurotomaria* near to *anglica*, Sow. Dogger, Blue Wyke. York Museum.
„ 6, 6*a*, 6*b*. *Trochotoma calix*, Phil. Dogger, Blue Wyke. Back, apical, and basal views.
„ 7. *Patella graphica*, Leck. Kelloway Rock, Scarborough. Bean Coll. British Museum. Apical view. 7*a*. portion enlarged.

(*To be continued.*)

IV.—CANADIAN ARCHÆAN OR PRE-CAMBRIAN ROCKS AND THE IRISH METAMORPHIC ROCKS.

By G. HENRY KINAHAN, M.R.I.A., etc.

[Read before the Royal Geological Society of Ireland.]

AS introductory to the subject of this paper, some observations made in Ireland on foliation, or the structure induced by metamorphism, with other phenomena connected therewith, will be submitted.

Students of Petrology and Lithology seem now in general to allow that there are three kinds of metamorphism, namely Regional and Contact, for which I have proposed respectively the terms *Metapepsis* and *Paroptesis*,[1] and Chemical change, to which King of Galway gave the name *Methylosis*, while more recently the Americans called it *Paramorphosis*. At the present time it is not intended to refer to the latter, as these preliminary remarks refer specially to the others.

In one and the same area Paroptesis or Contact metamorphism must necessarily occur at a different time to Metapepsis or Regional metamorphism; and the first may take place either before or after the other; or possibly there may have been two or more successive actions which affected the rock or rocks of one area; as, for instance, first in places there may have been Paroptesis, while subsequently these altered rocks were included in a Metapepsis area, while afterwards in portions, or the whole of the area Paroptesis or Metapepsis may again have taken place; because, as long ago pointed out by Lyell, vulcanicity often occurs over and over again, even with ages between, in one place or one area. In places the present structure of some of the Canadian Archæans would suggest that they were subjected to a succession of periods of alteration, some due to Paroptesis, others to Metapepsis; to this subject we will hereafter return.

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[1] Geology of Ireland, p. 175.

81.—PLEUROTOMARIA GUTTATA, Phillips, 1829. Plate IV. Figs. 3, 3*a*, and 4.

1829, 1835. *Trochus guttatus*, Phillips, G. Y. p. 112, pl. vi. fig. 14. K.R.
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1859. *Pleurotomaria arenosa*, Leckenby, Q.J.G.S. 1859, p. 12, pl. 3, fig. 1.
1875. *Pl. guttata*, Phil. } as distinct species. Phillips, G. Y. 3rd ed. p. 259.
Pl. arenosa, Leck. }

Compare also—

Pleurotomaria cincta (Münst), D'Orb., T. J. p. 560, pl. 420.
,, *galathea*, D'Orbigny, T. J. p. 566, pl. 423, figs 1–4.
,, *clathrata*, Münst. Goldf. Pet. 3, p. 71, plate 186, fig. 8.

Bibliography, etc.—I have not seen the type of *Trochus guttatus*, which belonged to Williamson, and should be in the Scarborough Museum. Phillips's figure is fairly characteristic, and shows the crenulated girdle very clearly. Our Figure 4 represents a fossil in a somewhat similar condition. D'Orbigny recognized Phillips's species as a *Pleurotomaria*, though Morris did not seem to have been satisfied on this point, probably because of the apparent want of the band of the sinus (slit-band). We cannot wonder that, when Mr. Leckenby obtained such a beautiful fragment as is depicted in our Figure 3, he should have fancied he had found a new species (*Pl. arenosa*).

The difference between *Pl. guttata* and *Pl. arenosa* seems to have been accepted by Phillips without question in his last edition. Yet it is evident that Mr. Leckenby finally regarded them as synonymous. The following note in the Woodwardian Museum testifies to this—"Under the title *P. arenosa* I have unfortunately described in my paper on the Kelloway Rock in the Geol. Journ. Feb. 1859, a specimen then in Bean's Collection, now in the British Museum, which on a subsequent examination of Phillips's *Trochus guttatus* in the Scarborough Museum, I find to be only a more perfect condition of the latter shell.

"Phillips's figure is that of partial cast, the only portion of the shell preserved being a thickened band at the suture."

Descriptions.—Specimen from the Kelloway Rock (zone 5), Scarborough. Leckenby Collection. Fig. 4.

Approximate	Height	30 millimètres.
	Width	40 "
	Mean spiral angle	89°.
	Ratio of body-whorl to entire height	50 : 100.

Shell conical, trochoid, much wider than high, moderately (?) umbilicated. The angle of the spire is slightly concave, so that between the opening of the spiral angle and the mean spiral angle there is a difference of some degrees. Number of whorls about 8, tapering to a sharp apex: the whorls are nearly flat, and their inclination about the same as the mean angle of the spire.

The ornaments consist of tolerably close spiral lines, which are decussated by axial lines, and more so in the posterior than in the anterior region. The base of each whorl is distinguished by a handsome crenulated girdle: just above this lies the band of the sinus (slit-band), which is narrow and projects slightly from the general level of the whorl. Cast of the body-whorl showing very faint traces of a carina. Other indications wanting.

Another specimen.—From the Kelloway Rock (zone 5), Scarborough. Bean Collection, British Museum. TYPE of *Pl. arenosa* REFIGURED. Fig. 3.

Approximate value of the spiral angle .... 92°.

Though broken and imbedded in matrix, portions of the shell are exquisitely preserved in spar tinged externally with brown oxide of iron. Owing to the prominence of the basal girdle, the shell is zoned rather than turrited. Posterior ¾ths of each whorl flat and sloping, remainder occupied by the girdle.

The ornaments consist of a reticulate system which occupies the posterior half of the whorl: in the penult this is very regular and slightly tuberculated at the nodes: in the centre of the space between this reticulate system and the girdle lies the band of the sinus, which is narrow and salient, but less salient than the girdle, which consists of four crenulated spirals welded together (see Fig. 3*a*). The cast of the last whorl visible is smooth, yet slightly angular at the turn. Other indications wanting.

Relations and Distribution.—The reticulate structure of the posterior portion of each whorl, the position of the somewhat narrow and yet prominent slit-band, and the crenulated belt at the base are characters of a group of *Pleurotomariæ*, which has many members. There are shells in the Inferior Oolite of Sherborne, which even show a connecting link between *Pl. guttata* and *P. granulata*, Sow., and it may well happen that from such the Oxfordian species now under consideration has been modified. The varieties of *Pleurotomaria* are so infinite wherever the genus is well represented, that authors have hardly known where to stop in naming specific forms. Hence it is possible that no absolute identification with continental fossils can be established in this case.

Pl. clathrata, Münst., from the "Jurakalke" of Pappenheim, has a tolerably close resemblance to the conditions represented by *Pl. arenosa*, but Goldfuss's figure is an enlargement. Mr. Leckenby considered that the species described by him was closely allied to *Pl. galathea*, D'Orb., also an Oxfordian species. In this case the spiral angle is about the same, yet in other respects there are differences of some importance. On the whole I am disposed to regard *Pl. cincta* (Münst.), D'Orb., as being the nearest to *Pl. guttata*, if not identical. The slightly concave angle of the spire in both is very similar. D'Orbigny says that *Pl. cincta* is special to the Oxfordian, occurring both in France and Germany. Whether his species is really the same as *Trochus cinctus*, Münst., is another question.

Pleurotomaria guttata is confined, in Yorkshire, to the Kelloway Rock, where it is rather rare.

82.—PLEUROTOMARIA ANGLICA, Sowerby, 1816. Pl. IV. Fig. 5.

1816. *Trochus similus* (sic), Sowerby, Min. Conch. pl. 142; *T. anglica* in Index to vol. ii.

1848. *Pleurotomaria undosa*, Deslongch., Mém. Soc. Linn. Norm. vol. viii. p. 77, pl. 12, fig. 2. Upper Lias.
1849. *Pleurotomaria anglica*, D'Orbigny, Prod. i. p. 214. Et. Siném.
1854. *Pleurotomaria anglica*, Sow., Morr. Cat. p. 271. Lias; Yorkshire, Somerset.
1876. *Pleurotomaria undosa*, Sow., Tate and Blake, p. 339, pl. 9, fig. 1. Mid. Lias.

Bibliography, etc.—Since this is essentially a Liassic rather than an Oolitic species, I feel scarcely justified in criticizing the literature. The Dogger fossil is not unlike Sowerby's type; but if there is a difference, it leans perhaps more to the *undosa* variety. Sowerby says that Lister found *Pl. anglica* at Bugthorpe, in Yorkshire, and figured it in his Conchology.

Description.—Specimen from the Dogger (zone 1), Peak (Blue Wyke). York Museum.

Approximate	Height	60	millimètres.
	Width	56	,,
	Spiral angle	75°.	

Shell of large habit, trochiform, strongly turrited: height and width nearly equal. Whorls about 8, increasing by steps within a tolerably regular angle. The carina is situated towards the upper part: it is coarsely tuberculated, the tubercles being depressed and drawn out spirally: the entire shell seems to have been pervaded by a system of fine spiral lines.

The band of the sinus is very conspicuous in the body-whorl, and is situated rather less than half-way between the carina and the margin of the base. It constitutes a slight prominence, and seems to show the "three central striæ" mentioned by Sowerby in his diagnosis.

Relations and Distribution.—Owing to the imperfect condition of the shell, an absolutely correct identification of the Dogger fossil with this or that member of the *anglica*-group is almost impossible. It comes very near *Pl. araneosa*, Desl. (cf. D'Orb. T.J. p. 416, pl. 352, figs. 5–9), a Middle Lias species, but in that one the band of the sinus is in a slight depression, whereas in our shell it occupies a slight prominence. The large *Pleurotomariæ* of the French Bajocian are all different from this one, and so are those of Dorset-Somerset as far as my knowledge extends.

The highly ferruginous matrix and other indications convince me that the specimen figured belongs to the Dogger proper, and not to the Dogger Sands. But a specimen was found lately by Mr. Walter Keeping, which I understood him to say had been obtained from the sands that carry the Dogger. There are three specimens in the York Museum. I know of none others from this horizon.*

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* 1. There is nothing absolutely exceptional in the reappearance of Liassic forms in the Inferior Oolite. We have a remarkable instance of this in the presence of large specimens of *Ammonites fimbriatus* in the *Humphresianus*-bed at Oborne, near Sherborne. In that case there can be no doubt that a few individuals of *Am. fimbriatus* lived to witness the reign of the coronati.

2. There are two species of *Pleurotomaria*, in addition to the four already detailed by me, included in the list of the "Geology of Yorkshire" (3rd ed. p. 259), of whose title to be regarded as Yorkshire fossils I can find no evidence. These are:

Pleurotomaria bicarinata, Sow., t. 221. Calc. Grit, Gristhorpe.
Pleurotomaria cingulata, Phil. Calc. Grit, Scarborough.

Some of the varieties of granite are also remarkable for the massive character of their crystallization, more especially the pegmatites. This, among others, is very conspicuous in the white mica pegmatite of the Vale of the Du Leivre, the felspar being in considerable masses, while the plates of the white mica are in places over nine inches across.

These pegmatites belong to Sterry Hunt's "Endogenous rocks"; he suggesting that the minerals crystallized out of solution. Such a supposition can be easily understood when pegmatite is found in small masses or in lenticular veins; but it is not so easily conceived when we have to treat with large masses.[1] Still, however, it is possible, if not probable, that Sterry Hunt may be right; as in great thicknesses of rocks there is no reason why there should not be vast vugs filled with mineral solutions; and when the minerals crystallized out, they would fill such cavities, thus forming masses of pegmatite or other rocks that had a similar genesis. In the Aughbowle district, co. Wicklow, there is a pegmatite locally called "Bastard Granite," a variety of which is the "Plumose Granite" of Jukes. This rock occupies a considerable area, and is somewhat like the Canadian pegmatite, although not as coarsely crystalline. From it I would suggest, that it is probable the coarse crystallization of pegmatite may be original structure and not due to subsequent metamorphism; the mass of this Wicklow pegmatite is newer than the normal Leinster Granite (Haughton's type), and consequently ought to be younger than the time of the Regional Metamorphism; as there is no newer metamorphism recorded in its vicinity that might have affected it. At the same time, the Canadian rocks are so much older, it is quite possible that their crystallization may have been augmented by metamorphism.

In the Province of Ontario and the neighbouring portion of the Province of Quebec, the Archæan rocks are divided up into Huronians and Laurentians. Selwyn has pointed out, that these divisions, although lithological, have not been proved to be petrological; while as far as I can learn, Logan has not stated that he had found any proofs of their being petrological groups. On the other hand, however, Dawson (Sir J. W.), Sterry Hunt, and others seem to insist that they are not only lithological, but also petrological groups.

A rock that appears to be considered a typical Ontario Laurentian is a pinkish or flesh-coloured fine-grained gneiss. Hand-specimens of this gneiss are undistinguishable from some of the rocks of the Cambrians of the Saltees and Forlorn, S.E. Wexford, of the Cambro-Silurians, counties Wexford and Wicklow, of the Cambro-Silurians, co. Galway, of the Cambrian (?) of Erris, co. Mayo, and of the Cambro-Silurians and Cambrians (?) of the co. Donegal. Some of these metamorphic rocks, as for instance those at Forlorn, were evidently originally felspathic and probably tuffose stratified rocks; this probably was also the case in many places where similar gneiss occurs in the counties Galway, Mayo, and Donegal; but there are also in those places, and in the co. Wicklow, similar gneisses that evidently were originally intrusions of felstone or felsite. In the high ground called Chelsea Mountains, Ottawa county, there is a granitoid gneiss very like some of those of Galway, Mayo, and Donegal; this is a rock intermediate in structure between those just mentioned in Ontario and the coarse gneissic granite of Chicoutimi,[1] Mont Calm, etc., of the province of Quebec; these rocks apparently all being more or less similar in their constituents, but having been subjected to different degrees or periods of metamorphism.

Here in connection with the Chelsea district may be mentioned the schistose rocks between the highland and Chelsea settlement; as with them there are calcareous and allied rocks exactly similar to rocks in the "Ophiolite and Dolomite series" of the Twelve Pins or Bennabeola district, co. Galway.[2] These Irish rocks have been suggested by William King, Galway, to be of Cambrian age, while my examination of the district seems to go to confirm this opinion.[3]

Before proceeding further, it appears necessary to mention some peculiar Irish calcareous rocks. These are found at the base of the Lower Carboniferous Sandstone, Co. Clare, at or near the base of the Devono-Silurian rocks of Mayo and Galway, and at different horizons in the Cambro-Silurians and Cambrians of Donegal, Sligo, Mayo, Galway, Waterford, Wexford, and Wicklow. These calcareous rocks are more or less intimately connected with basic eruptive rocks and to me appear to be adjuncts of vulcanicity.[4] In the township of Buckingham and elsewhere in Ottawa county there are apatites (phosphate of lime), that make very like the above-mentioned Irish Cambro-Silurian and Cambrian (?) limestones as they are associated and more or less intimately connected or entangled with the basic eruptive rocks. In connection with these, it may perhaps be allowable to suggest, that originally they possibly were carbonates; but that in some way, not yet explained, but at the same time being an adjunct of metamorphism, they were changed into the phosphate.

The rocks which par excellence are classed as Laurentians belong to the lithological groups for which I have proposed the names "Gneissic Granite or Granitoid Gneiss" and "Gneiss series"; while the Huronian rocks par excellence belong to the group called "Schist series" and "Sub-Metamorphic rocks."[5] In these general classifications, however, there are exceptions; because, as in Ottawa county, there are included in the tracts at the present time mapped as Laurentians[1] greater or less exposures of schistose rocks; while among the Huronians, gneiss occurs. This is similar to what occurs in the old country; as always in a tract belonging to the "Gneiss series," and even often in the "Gneissic Granite," subordinate schistose rocks appear, while in the "Schist series," and even in some places in the "Sub-Metamorphic rocks," subordinate gneiss occurs. From ocular demonstration it is evident, as has been already mentioned, that the Laurentians and Huronians are lithological groups; but are they also petrological, that is, geological groups? This we have now to consider.

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[1] Some of these rocks I learn from Dr. George Dawson, during last summer's explorations, have been proved to belong to the Laurentians and not a separate group.

[2] Geology of Ireland, chapter i. p. xxi.

[3] These rocks were suggested by the late Sir R. I. Murchison to be Laurentians; he however subsequently changed his opinion. In the late proposed classification of the West Galway rocks, these have not been included in the so-called Archæan rocks; that distinction being given to the more metamorphosed, but younger rocks in the country to the southward;—rocks that have been proved by their fossils to be of Cambro-Silurian age.

[4] Geol. of Ireland, chap. xii. p. 194.

[5] Geol. Ireland, chap. x. p. 177. As a rule the Huronians seem to belong to the "Schist series," but some of the Huronian limestones and associated rocks between Port Arthur and the Rat Portage belong to the rock called by Indian geologists "Sub-Metamorphic rocks." Some of these limestones are very little altered.

In the Province of Ontario there are numerous junctions of the Laurentians and Huronians. Those that seem most known and have been more generally studied occur more or less in the neighbourhood of the Canadian Pacific Railway, between Port Arthur and Winnipeg; and of these the one to which the greatest attention has been directed is the section at the rapid of the outfall of the Lake of the Woods near Rat Portage. This junction is stated by Sir J. W. Dawson and others to be a "Fault boundary." Such a statement cannot be lightly passed over, especially by an Irish geologist, when he thinks of the intricate boundaries in S.E. Ireland (cos. Dublin, Wicklow, and Wexford) between the Cambrians and the Cambro-Silurians, that were first unravelled by Jukes; especially those in the neighbourhood of Carrick Mountains and Glenealy, co. Wicklow, and at Poulshone and Bannow, co. Wexford. As, from the light supplied by Jukes, I was able to satisfy myself that such intricate unconformities may occur, I should be rash to state that somewhat similar unconformabilities did not occur in Ontario; yet at the same time I may be allowed to make suggestions,—or to say that I could not find any satisfactory reasons for supposing that there is an unconformability between the Huronians and the Laurentians.

Here we may digress and ask what are geological—that is, petrological divisions? Years ago I have heard American geologists state that the European maps are more lithological than geological; and the more the subject is studied, the more reasons appear to believe they are right in this opinion; as the major number of the divisions on these maps partake more of lithological grouping than of being natural petrological, that is, geological, divisions. This is especially the case in reference to the Kainozoic and Mesozoic rocks; as the different groups in them are merely lithological groups; but it is not so much the case in the Palæozoic rocks, as in the latter the groups for the most part have a claim to be petrological; but not always, as the rocks between the Carboniferous and the Cambro-Silurian are still in a higgledy-piggledy condition. The subdivisions, however, are only lithological, as is demonstrated by a comparison of the rocks of Ireland with those of England; the sub-groups that occur in regular succession in the English groups being quite mixed up in the Irish ones.[2]

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[1] Selwyn has specially mentioned, that the present boundaries and mapping of this county is only provisional, and that hereafter there will, probably, be found in it tracts of rocks belonging to the Huronians.

[2] It has been stated,—palæontological evidence proves these different groups

This confusion of lithological and petrological groups in the geology of the present time appears to me to be a most important consideration in the present inquiry, because, if such a classification is allowed, the Canadian groups have as much right to be called "geological divisions" as many, so called, in England or rather in Europe.

The mistakes that may occur by substituting lithology for petrology I may attempt to illustrate by facts observed in Ireland. For the uppermost group of the Irish Cambro-Silurian the term "Slate series" has been suggested, as in general it consists of argillaceous accumulations, also as in it all the principal veins of roofing slates are found; while for the lowest group of the same formation the term "Black Shale series" has been proposed, the rocks in it being also for the most part argillaceous, but at the same time carbonaceous and of a blackish colour. In both groups, however, in places, thick masses of arenaceous rocks may, often suddenly, cut out the argillaceous rocks. This is the case in the western extension of the Croghan-Kinshella hills to the N.E. of Carnew, Wexford, where in the "Slate series" a considerable thickness of grit suddenly appears in the slates; while in the Erriff Valley, co. Mayo, a mass of lithologically identical grits appear in the "Black Shale series" Now, if the rocks in these two far-apart districts were subjected to exactly the same degree of metamorphism, and under exactly the same conditions, we should have two groups lithologically similar; but petrologically or geologically very different; also in both localities the change from one group to another would be marked, as in both these places the argillaceous rocks are suddenly replaced by arenaceous; therefore, if metamorphosed, in both cases there should be hard boundaries between the metamorphosed grit and metamorphosed slates,—one probably being gneiss and the other schist.

In different places in Ireland there are tracts of gneissic rocks more or less similar to the Canadian Laurentian, yet evidently they belong to distinct geological groups. Of these, those in S.E. Wexford, Carnsore district, are probably of Cambrian age, while those of north Wexford in the Croghan-Kinshella range undoubtedly belong to the Upper group ("Slate series") of the Cambro-Silurian; while those of the counties of Galway and Donegal may in part belong to the Cambro-Silurian and in part to the Cambrian;[1] in Erris, N.W.

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this however does not appear to be proved. The different flora and fauna were developed and flourished under such conditions as were most favourable; and consequently each different group is most conspicuous, in more or less similar groups of strata; and for this reason such strata are said to be of one age. This often is hard to disprove, on account of not being able to trace the rocks from one place to another; but when we are able to do so, as is the case with the Carboniferous rocks of Ireland, it is found that the so-called divisions are only lithological. This can also be seen in the Irish Devono-Silurian; take, for instance, the Culfin section, co. Galway, where the lowest rocks contain Llandovery and Wenlock fossils, while over them are strata containing Caradoc fossils, which are succeeded by rocks having typical Wenlock and Ludlow fossils, while in the group above them, according to Davidson, the prominent and nearly only fossil is of a Llandovery type.

[1] In both these counties these gneissose and granitic rocks are evidently, at least in part, younger than the associated rocks, which have been proved to be, or are probably, of Cambro-Silurian age.

Mayo, they may be metamorphosed Cambrians; in east Mayo, Sligo, and Tyrone, they are possibly Cambro-Silurians or Upper Cambrians, that is, the representatives of the Arenig rocks of Wales; while in the co. Antrim, in the Ballycastle district, they are either Cambro-Silurians or Cambrians. All these lithologically belong to one group, while petrologically they represent different groups, belonging to different geological ages.

It should be pointed out that, as a general rule, hard well-defined boundaries are characteristic of excessively altered rocks; while partly or unaltered rocks usually graduate into one another by alternations of intermediate kinds of rocks; thus limestones in general graduate into argillaceous rocks, and the latter into arenaceous rocks; while a mass of arenaceous rocks will usually at its margin first alternate with argillaceous rocks, before the latter predominate.

The subject of hard boundaries to metamorphosed rocks has been discussed in Chap. x. of the Geology of Ireland, where it is illustrated that, in general, small altered tracts in large unaltered areas have well-marked boundaries; while here I would point out that in large areas of granitoid rocks, like those of Galway and Donegal, there are facts which indicate that the metamorphism which invaded the rocks was long subsequent to their original accumulation; as prior to their metamorphism they were upturned, contorted, displaced by faults and denuded, while subsequently such ruptures and breaks were sealed up by the metamorphic action; as proved by the breaks in the less altered rocks being much more numerous than in the granitoid rocks, while all in the latter are also found in the former.

Many of the phenomena mentioned as occurring in the Irish rocks may not directly apply to the Canadian, but indirectly they do; as they go to prove that too much reliance must not be placed on merely lithological characters. Furthermore, although there are many varieties of the Canadian Archæan rocks for which there are no equivalents in Ireland, yet there are also many that have. Already the great similarity between the gneiss of the two countries and of the calcareous rocks has been pointed out; while there is even a greater similarity between the metamorphosed basic eruptive rocks, if one set is compared with the other. It was remarkable in the section between Port Arthur and Winnipeg, also in Ottawa County, and other places in the Province of Quebec, the few rocks I saw with which I was not previously acquainted.

To return to the boundaries of the Ontario Laurentians and Huronians. All those I saw strongly suggested that they are more lithological than petrological, as in no place does there appear to be a regular or well-marked unconformability or even an overlap of the Huronians on the Laurentians; while at each side of the boundary there are striking similarities in the direction and dip of the beds in both classes of rocks; also all breaks, faults, and such like in the supposed older rocks appear also to occur in the supposed newer rocks. There not even being such marked differences in character between these Laurentians and Huronians, as are common in the Irish Cambro-Silurians, between those altered into schists and those altered into granitoid rocks.

If we compare small things with great, a parallel may be drawn between the section of metamorphosed Cambrian rocks at Forlorn Point, co. Wexford, and the section at the Rapids out of the Lake of the Wood, one being a pocket edition of the other. In the Forlorn Point section going southward, we first meet schists, then a hard boundary, then gneiss, and the latter after a time graduates by alternations into schists. In the Canadian section going northward, first you meet schists, then a hard boundary, south of which is gneiss; and the latter still further north having in it alternations or subordinate beds of schists: while there is also a bay that seemed to have been denuded into softer strata than the gneiss; of this, however, I could not satisfy myself, as the nature of the country and time did not permit.

I am aware that Sterry Hunt and others have suggested that these older rocks accumulated under circumstances quite different to those of the accumulation of the younger rocks; they in a great measure being more chemical than sedimentary accumulations. Such a supposition, however, now that I have been able to study the Canadian rocks, appears to me unnecessary, as these supposed chemical accumulations have their characters in common with rocks of the old country,—rocks whose characters can be proved by ocular demonstration to be due, not to chemical accumulations, but to metamorphic action,—that took place long subsequent to their original deposition.

Some of the suggestions that I have put forward in this paper may possibly have already been ventilated by American geologists. If this should happen to be the case, I beg leave to assure the originator of the suggestion that his claim has been ignored not purposely, but on account of my being unacquainted with the paper in which it was put forward.

V.—A Revision of the Antelopes of the Siwaliks.

By R. Lydekker, B.A., F.G.S., etc.

A FEW years ago I described[1] some remains of Antelopes from the Pliocene Siwaliks of India, when I employed the generic term *Antilope* in the wide sense in which it was used by the older zoologists and palæontologists. At a later date[2] I was enabled to refer two of the species thus designated to two of the genera of Antelopes as at present classed; and at the same time mentioned some other forms. A recent examination of all the remains of this group from the same deposits contained in the British Museum has enabled me to make a more exact determination in the case of another of the species mentioned in my first notice, and also to indicate the existence of other forms closely allied to existing African Antelopes. These new forms I hope to have an opportunity of describing on a future occasion, and, therefore, now content myself with merely giving a list of the species which I can at present recognize. The ill-defined character of some of the genera of existing Antelopes renders it in many instances a matter of extreme difficulty to be quite sure as to the affinities of their fossil relations.

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[1] Palæontologia Indica (Mem. Geol. Surv. Ind.), ser. 10, vol. i. pp. 154–9 (1878).

[2] *Ibid.*, vol. iii. pp. 127–8 (1884).

1. Oreas (?) latidens, *nobis.*

Vide Pal. Ind. ser. 10, vol. iii. pl. xiii. figs. 12, 13.

Founded on the upper dentition, which closely resembles that of the Eland.

2. Strepsiceros (?) Falconeri, n. sp. *nobis.*

Founded on an immature cranium in the British Museum (No. 37262) from Perim Island (Gulf of Cambay). This specimen shows the bases of the horn-cores, and agrees so closely in general characters with the cranium of the existing species of *Strepsiceros* that it evidently indicates a closely allied, and very probably generically identical, form.

3. Palæoryx (? sp.

Vide Pal. Ind. *op. cit.* figs. 9, 10.

Indicated by molars resembling those of the Pikermi forms of this genus.

4. Boselaphus, sp.

Vide Pal. Ind. *op. cit.* figs. 1, 2.

Described upon the evidence of the upper dentition.

5. Hippotragus Sivalensis, *nobis.*

Vide Pal. Ind. *op. cit.* vol. i. pl. xxv. fig. 1, 2 (*Antilope*).

Originally founded on a female cranium with the crowns of the molars hammered off, and considered to be allied to *Antilope cervicapra*; from which it is, however, widely different. An immature cranium of a male in the British Museum (No. 39558) indicates that this form is closely allied to the existing African *Hippotragus niger*, and may, at least provisionally, be referred to that genus.

6. Gazella porrecticornis, *nobis.*

Vide Pal. Ind. ser. 10, vol. i. pl. xxv. fig. 4 (*Antilope*).

Founded on a frontlet and horn-core.

7. Alcelaphus palæindicus (Falconer).

Vide 'Falconer's Palæontological Memoirs,' vol. i. pl. xiii. (*Antilope*).

The cranium (B. M. No. 39594) strongly resembles that of *Alcelaphus tora*, but the direction of the horn-cores is more like that obtaining in *A. albifrons* and *A. pygargus.*

8. Alcelaphus Bakeri, n. sp. *nobis.*

This species is founded on an immature cranium in the British Museum (No. 39598), with a shorter face and more approximate horn-cores than the last species, and presenting a very strong resemblance to that of *Alcelaphus pygargus.*

Generically undetermined forms.

9. Species *a* (resembling *Cobus*).

Two fragments of frontals and horn-cores (B. M. Nos. 18785, 18785*a*) from Perim Island, indicate a very large Antelope with depressed frontals, resembling *Cobus.*

10. Species *b* (apparently allied to *Cobus*).

The hinder portion of a cranium (B. M. No. 39559) indicates a smaller animal than the last, agreeing very closely in general characters with the African genus *Cobus*, but perhaps too imperfect for generic determination.

11. Species *c* (*Antilope patulicornis, nobis*).

Vide Pal. Ind. ser. 10, vol. i. pl. xxv. fig. 3.

The hinder part of a cranium (B. M. No. 39559*a*) agrees with the type frontlets of this form, and apparently indicates a species allied to the two preceding ones; but with more divergent horn-cores.

12. Species *d* (of uncertain affinity).

The hinder portion of a cranium in the British Museum (No. 39559*b*) belongs to a species distinct from any of the foregoing, of which the affinities are by no means clear. It closely resembles an imperfect cranium from the Lower Pliocene of Pikermi figured by Gaudry in the 'Animaux Fossiles et Géologie de l'Attique,' pl. lii. fig. 1.

VI.—ON THE MODE OF OCCURRENCE OF GOLD IN THE TRANSVAAL GOLDFIELD.

By E. J. DUNN, Esq.

I VENTURE to submit the subjoined account of the mode of occurrence of gold in certain localities in the Transvaal Gold-field, in the hope that it may prove of interest to some of your readers.

At the "Waterfall" Diggings thin leaders, ranging from half an inch to eight or nine inches, and having a dip of about 50°, cut through nearly horizontal strata of shales, soft sandstones, decomposed calcareous beds, etc. The leaders consist of siderite and quartz, the siderite frequently preponderating. Sections of these leaders show sometimes walls of siderite, with quartz in the centre; and in other cases the walls are of quartz, with siderite in the centre. The proper walls of the vein are frequently mineralized back several inches from the junction with the "country." Where so mineralized, cubes of iron-pyrites in an oxidized condition are abundant, and gold also occurs.

The interesting point in connexion with these auriferous leaders is that the gold is almost invariably associated with the siderite. I did not observe a single instance in which the quartz was penetrated by gold; whereas the siderite is frequently thickly studded with gold in the form of small plates, in arborescent forms, and in minute particles. The siderite is altered, but still preserves its distinct cleavage. It is dark-brown in colour, and in places is stained black by manganese oxide. The quartz is translucent, and bears the impress of the rhombohedrons of siderite.

Associated with gold in these veins are native bismuth, carbonate of bismuth, yellow sulphuret of copper, muriate of copper, oxide of copper, and hematite. There are a great many of these leaders, and nearly all are auriferous, and most are richly so.

"Woodward's leaders," at Spitzkop, cut through similar rocks; but, though siderite is present, it is less abundant; the veins here consist principally of quartz. In the deeper workings white unaltered siderite is found, with gold in it. There are very many leaders at this locality; at least thirty are already worked. They run parallel, and range from one-eighth up to six inches in thickness. Where they cut through certain beds of very fine, argillaceous, dove-coloured shale, these leaders become extremely rich. The veins generally contract at these intersections, and swell out above and below. Often the width of the vein at such spots is not more than one-eighth to one-fourth of an inch in thickness, and the whole width is occupied by gold. Plates of solid gold, filling the veins where so narrow, have been found, weighing from one to ten ounces each. A few crystals of iron-pyrites (oxidized) occur in the quartz. The "country" does not appear to have become mineralized back from the veins. As at "Waterfall," the gold appears to have been associated with the siderite, for which it had a greater affinity than for the quartz, and seldom are the gold and quartz found intimately blended.

At "Ross Hill" iron-pyrites of large size—some crystals weighing 2 lbs. and more—and in groups of crystals weighing many pounds, are abundant; the quartz of the veins is pitted with thin hollow casts. All the pyrites are oxidized, and many of them show gold, not only on the outside, but in the heart of the crystals. The crystals are frequently modified dodecahedrons.

At "Brom's Hill," "Ophir Hill," and the "Company's Reef," Grasskop, the quartz veins (generally "flat leaders") are thickly pitted with the cubic casts of pyrites; and many of these veinstones prove highly auriferous, the gold being impalpably fine (dust gold).

At "King's Claim," Spitzkop, one of the richest spots yet found on these Gold-fields, the gold occurs in a sort of soft breccia of sandstone, shales, etc., interpenetrated by diorite in a soft state. It is found in plate-like pieces, from a pennyweight up to two or three pounds weight each. The gold is associated with a ferruginous earth; and quartz appears to be almost entirely absent, and is certainly not the matrix in this instance.

In "McIntosh's Reef," Swaziland, gold in small particles occurs, associated with native bismuth, in the heart of the quartz, which is somewhat greasy-looking, and occurs in a much older formation (schist) than the veins previously mentioned.

Crystals of gold occur at Woodward's leaders and at Silo and Tait's Claims, Spitzkop.

At "Frankfort" and "Hermansberg," on the Blyde River, a remarkable saccharoidal quartz is in parts richly auriferous; oxidized iron-pyrites and their hollow casts are numerous. The gold varies from the size of a large pin's head to "flour gold."

At "Pritchard's Reef," and "Rautenbach's Reef," near the "Kantoor Diggings," a large area of diorite, in a decomposed state, is penetrated in all directions with quartz-veins. Oxidized pyrites are also present, and "flour gold" appears to be distributed through the whole mass.

As may be inferred, there are few localities where gold occurs under such varying conditions as in the Transvaal Gold-fields.

VII.—On the Occurrence, as a Common Rock-forming Mineral, of a Remarkable Member of the Enstatite Group (Amblystegite, *vom Rath*).

By Prof. John W. Judd, F.R.S., Sec. G.S.

During recent years, much attention has been directed to the importance of the Rhombic Pyroxenes (Enstatites) as rock-forming minerals. In 1879 Prof. Fouqué showed that hypersthene is a common mineral in the Santorin lavas, and in 1883 Mr. Whitman Cross demonstrated that there exists a large and important class of andesites, distinguished by the presence in them of the same mineral hypersthene. Mr. Teall, in the pages of this Magazine, has pointed out that similar lavas exist in this country, which are undoubtedly of pre-Tertiary age; and, now that the attention of geologists has been very generally drawn to the subject, the same rocks have been recognized by many observers in all parts of the globe.

The class of the Rhombic Pyroxenes, or Enstatites, comprises the bisilicates of magnesia, in which a varying proportion of that base may be replaced by ferrous oxide. This replacement of the one base by the other results in striking modifications in the colour, appearance and optical constants of the mineral, but does not appear to appreciably alter the outward crystalline form. Three chief types of the rhombic pyroxenes have been very generally recognized—the non-ferriferous (enstatite), the slightly ferriferous (bronzite) and the highly ferriferous (hypersthene); but much difference of opinion has existed concerning the definition and limits of these three species. Tschermak has proposed to confine the name of enstatite to those rhombic pyroxenes in which the proportion of iron falls below 5 per cent.; to give the name of bronzite to those in which the percentage of ferrous oxide lies between 5 and 15; and to call by the name of hypersthene all those containing more than 15 per cent. of ferrous oxide.

But there are certain rhombic pyroxenes in which the proportion of ferrous oxide is exceedingly high, ranging from 25 to 35 per cent., so that this base is largely in excess of the magnesia, and in these the physical properties are so entirely different from those of the typical unaltered hypersthenes that it seems desirable to give them a distinct name. The most conspicuous character of these excessively ferriferous enstatites, is their very striking pleochroism. The thinnest plates give with the dichroiscope tints varying from a rich red, like that of garnet, to a vivid blue-green.

Instead of proposing a new name for these very highly ferriferous enstatites, it appears to me to be desirable to revive the old name of "Amblystegite," which was proposed by vom Rath for a mineral of this class in the year 1869.

I have recently found that this remarkable and very beautiful mineral is by no means uncommon as a rock-constituent. It occurs in rocks of several different classes—quartz-diorites, diorites, dolerites, gabbros, and certain ultra-basic rocks; and the rocks containing this mineral are certainly very widely distributed, for I have already found examples of them, not only in several parts of the British Islands, but among specimens from Western Africa, India, and the Pacific Islands.

I am now preparing descriptions of the rocks containing this interesting mineral, in which I shall fully discuss its physical characters, and the analyses which have been made of it. As the mineral appears to be by no means uncommon, however, I have thought it well to call attention to it in this preliminary note.

VIII.—THE CAUSE OF SLATY CLEAVAGE. SHEARING *v.* COMPRESSION. A REPLY TO MR. HARKER.

By the Rev. O. FISHER, M.A., F.G.S.

IT has given me much satisfaction to see Mr. Harker's criticism of my theory of cleavage, because I think few stronger champions could be found for the older hypothesis. His remarks deserve a reply. I first give Mr. Harker's description of the theory which I have endeavoured to supersede. The changes which have induced cleavage "were ascribed to great lateral compression of the rock in the direction perpendicular to the cleavage-planes, together with some expansion along those planes in the line of their dip."[1] And, although he has not incorrectly described my theory, I prefer to restate it in the words I used at the end of my paper on "Faulting, Jointing, and Cleavage." The internal movement, which has produced cleavage, "would have been accomplished by faulting, had not the friction been too great, owing to pressure, to allow of sliding along surfaces of separation. Viscous shearing therefore performed the office and produced cleavage surfaces."[2]

Mr. Harker truly says that I "contend that the kind of distortion presented by the fossils of cleaved rocks is such as would be produced by a shearing motion." But I did not mean to deny the alternative, viz. that these appearances could equally have been brought about by compression combined with expansion, as indeed appears from my remark that the ellipsoid caused by shearing "corresponds with that given by Phillips" in his diagram;[3] and we know that he was attributing distortion to compression combined with expansion.

Mr. Harker evidently refers to Dr. Haughton's calculations,[4] where he says that the ellipsoid of distortion comes out something very like a flat oblate spheroid, which my theory would not explain. Dr. Haughton's method of calculating the form of the ellipsoid of distortion is ingenious, and I now believe correct in theory; but there are points connected with the author's application of it to actual instances, which I think present great difficulties. His law I. appears to assert, that the greatest "distortion or elongation" of a fossil is in the direction of the intersection of the cleavage and of the bedding, which must be the strike of the rocks. Does this agree with the experience of other observers? Also he brings out the ellipsoid of distortion to be commonly an oblate spheroid. In cases where the bedding coincided with the cleavage plane, this would cause fossils to be scarcely at all distorted; whereas in those I have seen they are usually much elongated in the direction of dip of cleavage. The great condensation of the material required by his result is likewise scarcely conceivable, except under the exceptional circumstance of its having been a shale before cleavage was induced. In such a case, the chief condensation would have occurred previously to the cleavage being set up, and ought not to be included in the results of that action. But Dr. Haughton's method of calculation does not afford any means of separating the two. The Tintagel fossils have much the appearance of shells which have been originally preserved in a shale, after the manner of the fossils from the Oxford Clay at Christian Malford.

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[1] GEOL. MAG. Dec. III. Vol. II. p. 15.
[2] GEOL. MAG. Dec. III. Vol. I. p. 276.
[3] Phil. Mag. Jan. 1856.
[4] Phil. Mag. 1856, vol. xii. p. 409.

If cleavage be, as I argue, due to a shearing action, the question whether the cleavage planes will be in the direction of the shear, or in that of the longer diametral plane of the ellipsoid of distortion produced by it, is perhaps an open one. In my first paper I suggested that the two sets of planes would coincide,[1] and I note that Mr. Harker would incline to this view, could he admit the theory at all. In my second paper, influenced by Sharpe's figures, I concluded the other way. It is possible this later conclusion may be too sweeping. But I feel pretty certain; that if the rock be of such a nature, that its constituent particles are all distorted, then cleavage must on the whole follow the distortion. If, however, it consists of hard particles imbedded in a less rigid matrix, so that those particles resist deformation and the matrix shears past them, then the cleavage may be less perfect, and may follow the shear. Those particles, eye-shaped in section, which occur in coarse slates and in schists, point to this kind of action; and their outline indicates stream-lines, in which the matrix has flowed past them in opposite directions on their opposite surfaces, and abraded or dissolved away their substance until they have been reduced to the lenticular forms which now guide the cleavage. There may be degrees of action intermediate between these extremes.

There is no difficulty in accounting for contorted layers of harder rock, interbedded with more yielding rock which shows cleavage, as at Ilfracombe. The mode in which this would be effected is excellently illustrated in some diagrams given by Stapff.[2] The effect produced would depend upon the inclination of the layers to the direction of the shear. If that were such that they made at first an acute angle with the direction of the shear, they would be more and more crumpled as the shear went on, until such time as the axis of the folds became perpendicular to the direction of the shear. When that position had been passed, they would begin to be straightened out again, were the material capable of sustaining tension. But as it is not, they would be pulled to pieces, and afterwards worn down into flattened fragments. In this manner a frilled schist may pass into a rock showing schistose cleavage in the direction of the shear, which will be parallel to the folds. This would explain what Mr. Teall has told me, viz. that he has seen facts in the N.W. of Scotland, which have led him to suspect some connection between "frilling" and schistosity; having noticed the one apparently pass into the other within a moderate horizontal distance.

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[1] GEOL. MAG., Dec. III. Vol. I. p. 269.

[2] Wie am Mte. Piottino die Parallelstruktur des Gneisses in Schichtung übergeht. Neues Jahrbuch für Mineralogie, etc., 1882, I. Band, pp. 92, 93.

It seems that, as the shear increased, the limbs of the folds of the frilling would be alternately compressed and elongated. This would give rise to alternate layers, in which the materials of the harder and softer original layers would be mingled in different proportions, and, if further metamorphosed, these would pass into alternate layers, in which the component minerals would not be similarly abundant. If, however, the bedding of the layers was at right angles, or at an obtuse angle, to the shear, they would never be crumpled at all, but begin at once to be torn to pieces. Thus it appears that even the same amount of shear, which at one locality produces frilling, may in another, not far off, produce schistosity: the difference of effect depending upon different inclinations between the layers and the shear at the two places.

This kind of action might affect a schist, and convert it into a frilled schist, and then back again into a schist having a different dip from the original one.

When we turn to the relation of cleavage to the structure of a district, we approach a more difficult branch of the subject, but the one which must, I believe, decide the mode of causation. The more we learn about earth movements, the more complicated we find them; witness the latest results of the Survey in the Eribol district. But from what we do know, I think a great amount of shear at certain places cannot be called improbable: and I am not prepared to abandon my somewhat bold hypothesis to account for the movements, by which I think cleavage might be superinduced upon already highly disturbed rocks.[1]

Mr. Harker combats this with a diagram implying that, on my hypothesis, we ought to meet with cleavage dipping in directions nearly at right angles upon the opposite flanks of a range of hills, but with none at the summit or in the plains. I however carefully guarded against being supposed to assert, that the outline of a district, such as I drew to explain the cause of vertical movements, in any way represented the present contour; saying that denudation would have entirely changed its aspect.

In the next place it does not follow that the settling down of a recently raised tract would take place by consecutive gradations from the outsides to the centre. More probably it would be great at places, and little or none through intermediate spaces. Some of the horizontal sections of the geological survey, carried through cleaved districts, convey this idea.[2] In fact, those readjustments of equilibrium, which in other cases have been accomplished by faulting, may in the circumstances have taken place through shearing. Of course this would not exclude faults formed antecedent to the cleavage, and which may have accompanied the elevatory movements.

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[1] *Loc. cit.* p. 271.

[2] Hor. Sections, 6, 26, 27, 29, 31, 32, 40, 113, 114, 115, 118.

But to return to the unfavourable instance which Mr. Harker has supposed. At the central portion there will be no shear, and therefore no cleavage. Where, on either side of this, the shear just commences, it would be too slight to induce perceptible cleavage. There the undeveloped cleavage would be at right angles to the undeveloped cleavage on the opposite side of the crest. But at distances from the centre, at which the shear, and therefore the cleavage, became pronounced, the two dips, though in opposite directions, would be steeper than to be at right angles to one another—as Mr. Harker has represented them. Neither, though the dip of cleavage is usually high, is it by any means always so.[1] But take the instance suggested as a difficulty; that is, suppose the shear to be vertical, and of such an amount as would cause the cleavage to be inclined at about 22° to it. Then the dip would be 68°—a by no means low angle.

The early observers of cleavage came to the conclusion that it was a feature produced by some very extensive cause, operating after the rocks had undergone great displacement. This is clearly at variance with the theory, that the pressure which caused the displacement caused also the cleavage. Mr. Harker makes no allusion to this point; nor to the particular instance, in which it seems to be illustrated, viz. by the section which I gave from the cliff at Hope's Nose. I am not aware of the exact evidence which led Sedgwick and the rest to this conclusion; but it seems to me to follow of course from the fact, that dip of cleavage is nearly independent of bedding. For fix the thoughts upon a material sphere within the rock undergoing contortion. If the pressure which causes the contortion also produces cleavage, this sphere will have been distorted into a flattened ellipsoid. If, at some later stage of the process, the stratum of which it forms a part be further rotated into a new position, the ellipsoid will be rotated with it, so that, if the formation of the cleavage preceded the contortion, the parallelism of the cleavage planes throughout a district would be subsequently destroyed. The same would be the case, though to a less degree, if the contortion and supposed cleavage-causing compression went on together. Neither must it be forgotten that the formation of cleavage according to the compression theory, and contortion, are two distinct modes of satisfying compression, and that the sum of the two would be constant; so that with the more of one, there would be less of the other. I cannot help thinking that, if cleavage had been induced by the same exertion of pressure which contorted the rocks, instead of the cleavage ranging in nearly parallel planes over considerable belts of country, it would lie in undulations more or less normal to the curvature of the folds, and not in planes independent of them.

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[1] Jukes's Manual, p. 271, ed. 1862.

REVIEWS.

I.—GEOLOGIE VON BAYERN. Von Dr. K. WILHELM VON GÜMBEL. Erster Theil: GRUNDZÜGE DER GEOLOGIE. I. Lieferung. Mit zahlreichen Abbildungen im Text. (Kassel, 1884.)

ALTHOUGH this work is entitled "Geology of Bavaria," yet the first part, containing the principles of geology, is altogether of a general character, and apparently has no special relation to Bavaria or other part of Germany.

The first part of the work treats of the Hylology of the Earth, that is, of the form and derivation of the materials of which the Earth consists. This is divided into five sections, which respectively refer to mineralogical, petrographical, morphological, petrogeneric, and palæontological subjects.

The first number of 208 pages large octavo, with 145 woodcuts, contains merely the first two sections relating to mineralogy and petrography. The author's classification of the different rocks has at least the merit of novelty, and we therefore venture to give an indication of its character. The first leading group named Kokkite is defined as an aggregate of chiefly crystalline particles, not in a slaty form. This is subdivided into Homokokkite, when the crystalline rock consists of only one kind of mineral, such as ice, rocksalt, gypsum; and Heterokokkite, when it is composed of different minerals with a crystalline, porphyritic, or amorphous ground-mass, such as granite, trachyte, etc. The second main group named Hyalite is defined as massive rock consisting of an amorphous glassy magma, without regular inclosures, such as obsidian and perlite. The third group is Phyllolithe, or thin-bedded rocks mostly of macrocrystalline constituents, such as quartzitic and mica schists, gneiss, etc. The fourth group, Pelolithe, consists of stratified, more or less massive, apparently homogeneous rock, containing an intimate mixture of small crystalline, clastic, and organically-formed particles. Rocks of such different characters as quartzite, limestone, and marl are examples of this group. The fifth group, Psepholite, embraces stratified rocks consisting chiefly of readily recognizable fragments of older broken up rock-masses, either loose or firmly united by some cementing material. Under this are included, amongst others, sand, sandstone, conglomerate, boulder-clay, volcanic tuff, etc. The sixth and last main group, named Organolithe, is defined as stratified rock consisting chiefly of remains of extinct organisms. This embraces chalk, deep-sea mud, diatomaceous earth, and coal.

We are afraid that in practice this classification will prove somewhat puzzling, since many stratified rocks will come under two or even three of the leading groups.

The descriptions of the different kinds of rocks appear to be very satisfactory and reliable, and particular attention is given to their microscopic structure, which is illustrated by numerous well-executed woodcuts. These give this work a distinctive feature, and render it highly valuable to the student.

We remark in passing that the Laurentian eozoonal limestone is placed with rock-salt and gypsum in the Homokokkite division, from which we presume that the author is at least convinced of the inorganic nature of this rock, though his statement respecting it is not very explicit (see p. 97). G. J. H.

II.—GEOLOGICAL SURVEY PUBLICATIONS.

1.—GUIDE TO THE GEOLOGY OF LONDON AND THE NEIGHBOURHOOD. By WILLIAM WHITAKER. Fourth Edition, 1884, pp. 89. Price 1*s.*

This is undoubtedly one of the most successful publications issued by the Geological Survey of England and Wales; for no other memoir of the Survey has reached even a third edition. The "Guide to the Geology of London" has been published at a much lower price than the majority of the Survey Memoirs; it is printed in large type (though with indifferent ink), and above all it is written in a concise and readable style. The chief points in which this edition differs from the last are noted by Mr. Whitaker in his preface. Most important are the accounts of recent deep borings, especially that at Richmond; while the generalized section across the London Basin, showing the underground range of old rocks, has been modified in accordance with the fresh data furnished by the borings. Sections are also given of the Lower London Tertiaries, north and south of the Thames.

In another edition it would be useful to give the species as well as the genera of the commoner fossils that are met with; and perhaps an index-map might be furnished, after the plan adopted in the Explanation of Sheet 13, and some other Memoirs.

2.—THE GEOLOGY OF THE COUNTRY NORTH-EAST OF YORK AND SOUTH OF MALTON. By C. FOX-STRANGWAYS. 1884. pp. 40. Price 1*s.* 6*d.*

This Memoir contains a description of a large part of the Vale of York, including the geology of the city itself. The rocks embraced in the area comprise the Keuper, Rhætic Beds, Lias, Oolites (up to the Kimmeridge Clay), Neocomian, Cretaceous, Glacial and Post-Glacial deposits. Lists of fossils are given, and the labours of other observers are duly acknowledged.

3.—THE GEOLOGY OF THE COUNTRY AROUND DISS, EYE, BOTESDALE, AND IXWORTH. By F. J. BENNETT. 1884. pp. 44. Price 2*s.*

This Memoir contains an account of the Chalk, Glacial, and Post-Glacial deposits of parts of Norfolk and Suffolk. An appendix contains records of numerous shallow well-borings.

4.—THE GEOLOGY OF THE COUNTRY AROUND ATTLEBOROUGH, WATTON, AND WYMONDHAM. By F. J. BENNETT. 1884. pp. 31. Price 1*s.* 6*d.*

A portion of Norfolk is embraced in the area described in this Memoir; the strata described being Chalk (with lists of fossils), Glacial, and Post-Glacial deposits. Records of many well-borings are included.

5.—THE GEOLOGY OF THE COUNTRY AROUND FAKENHAM, WELLS, AND HOLT. By HORACE B. WOODWARD. 1884. pp. 57. Price 2*s*.

In this Memoir also a portion of Norfolk is described. The formations comprise Chalk, Crag, Glacial and Post-Glacial deposits. Lists of fossils from the Chalk and Crag are given.

6.—EXPLANATION OF HORIZONTAL SECTIONS. Sheet 128. Sections of the Suffolk Cliffs at Kessingland and Pakefield, and at Corton. By J. H. BLAKE. pp. 8. Price 2*d*.

In this short explanation Mr. Blake gives a concise description of the beds exhibited in the coast section. It is intended to accompany the engraved sheet of sections. The beds described belong to the "Forest-bed and Chillesford Series," the "Glacial Drift," and Recent deposits. The fossils of the various divisions are noticed, and considerable importance is attached to the "Rootlet-bed," which in the opinion of the author "shows a distinct break or unconformity between the Pliocene beds and the overlying Drift."

III.—A SKETCH OF THE GEOLOGY OF SUFFOLK. By J. E. TAYLOR, Ph.D., F.L.S., F.G.S. [Reprinted from White's History, Gazetteer, and Directory of the County.] Sheffield, 1884. Pp. 19.

EXCELLENT sketches of the geology of various English counties have been contributed from time to time to White's Histories. Thus the geology of Hampshire, and that of Leicestershire and Rutland were prepared by Mr. W. J. Harrison (1877); that of Devonshire, by Mr. M. Townshend Hall (1878); Lincolnshire, by Mr. Harrison (1882); and Norfolk, by Mr. John Gunn (1883). We have now been favoured by Dr. Taylor with a new edition of his Geology of Suffolk, the first edition of which was noticed in the GEOLOGICAL MAGAZINE for 1874 (p. 268). In the interval a number of papers dealing with the geology of this county have been published, and these are duly noticed by Dr. Taylor, who has himself contributed much to our knowledge of the local geology.

IV.—THE FOSSILS OF THE YORKSHIRE LIAS DESCRIBED FROM NATURE. With a carefully measured Section of the Strata, and the Fossils peculiar to each. By MARTIN SIMPSON. Second Edition, 1884. Whitby (sold at the Museum); and London, John Wheldon. Price 6*s*.

MR. SIMPSON is well known to geologists who have investigated the sections on the Yorkshire coast, as the Curator of the Whitby Museum, and as a most enthusiastic student of the fossils of the district. For nearly fifty years he has occupied his post at the Museum, and early in 1843 (as he tells us in the preface to this volume) he published descriptions of more than one hundred

Ammonites of the Yorkshire Lias, in a short Monograph. Later on, in 1855, he published descriptions of all the then known fossils of this formation, together with an outline of the Geology of the Yorkshire Coast, intended as a guide to strangers. In the fourth edition of this "Guide" (published in 1868) he gave a section of the Lias, carefully measured in detail, and noted the fossils which he had collected from each stratum. This section is now reprinted, with slight alterations, and the fossils, recorded in the work before us, are referred to their particular horizons in the section. The estimates of the thickness of the Lias differ from those given by Messrs. Tate and Blake in their "Yorkshire Lias." The chief value of Mr. Simpson's work, however, consists in his records of the positions in which the fossils occur. His descriptions of the species, being unaccompanied by figures, will not, we fear, be of very great service to collectors.

REPORTS AND PROCEEDINGS.

I.—GEOLOGICAL SOCIETY OF LONDON.

(*Continued from p.* 137.)

January 28, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair. The following communications were read:

2. "On the Geology of the Rio-Tinto Mines, with some general remarks on the Pyritic Region of the Sierra Morena." By J. H. Collins, Esq., F.G.S.

After briefly describing the geographical position of the Rio-Tinto mines, and the occurrence at the same of pyritous ores amongst slates and schists which abut against gneissose rocks to the north, and pass under Tertiary beds to the southward, the author proceeded to consider the general characters and associations of the pyrites-deposits, and then gave a general account of the Rio-Tinto district. The slates were described, and the fossil evidence recapitulated upon which an Upper Devonian age had been assigned to them. Analyses were furnished to show the changes due to weathering and to infiltration. The various intrusive rocks (syenite, diabase, and porphyries) occurring in the schists were described, and analyses of them given. The sedimentary iron-ores and their composition were next noticed, and the author ascribed their formation to deposition in lakes.

The masses of pyrites which furnish the principal ores of Rio Tinto were then described, their mode of occurrence in fissures between dissimilar rocks explained, and their formation discussed. The different kinds of ore obtained from the mines were noticed in detail, and several analyses added, giving samples both of the mixed ores and of the pure minerals

The manganese-lodes were next described, and shown to be parallel to the pyrites-fissures, and frequently to be only branches of the latter.

A summary of the author's conclusions as to the stratigraphy of the district, the ore-deposits, and the surface-geology was appended.

3. "On some new or imperfectly known Madreporaria from the Great Oolite of the Counties of Oxford, Gloucester, and Somerset." By R. F. Tomes, Esq., F.G.S.

The main object of the present paper, which is supplementary to one already published in the Quarterly Journal (vol. xxxix. p. 168), was to describe a section of the Great Oolite at Milton, in Oxfordshire, another at the Lime-kiln quarry near Cirencester, and some outcrops of the same beds in the neighbourhood of Bath, on Farley Down, Combe Down, and Hampton Down, the localities from which so many of the types of corals described by MM. Milne-Edwards and Haime had been derived. Lists of the corals obtained from particular beds in each of the sections mentioned were given, and several of these corals were described as new, remarks been appended as to a few previously described forms. In conclusion, a brief description was added of the conditions under which the coralliferous deposits in the neighbourhood of Bath had been formed, and of their probable correlation with the Great Oolite strata of Oxfordshire.

II.—February 11, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the chair. The following communications were read:

1. "The Tertiary and Older Peridotites of Scotland." By John W. Judd, F.R.S., Sec.G.S.

The very interesting rocks known as "peridotites" have been regarded by many petrographers as peculiar to, and, indeed, characteristic of, the older geological periods; but in the Western Isles of Scotland there occur a number of rocks of this class, constituting portions of intrusive masses, which the author, in a previous paper, has shown to be the central cores of Tertiary volcanoes of vast dimensions.

These Tertiary peridotites are most intimately associated with the gabbros and dolerites, the felspathic and non-felspathic rocks passing into one another by insensible gradations, and the rocks of either class being intersected by veins of the other. The peridotites exhibit the same varieties of microscopic structure as the associated gabbros and dolerites, these structures being described under the names of "granitic," "ophitic," and "porphyro-granulitic."

The felspars, which are rare in the peridotites, are intermediate in composition between labradorite and anorthite; they rarely, however, exhibit evidence under the microscope of being built up of laminæ belonging to different species. The study of the lamellar twinning, which is a common, but by no means universal character in these felspar crystals, points to the conclusion that it has been induced by pressure or strain, like the similar structure in rock-forming calcite. The pyroxenes are represented by many varieties, both of the monoclinic forms (augites) and the rhombic forms (enstatites), the former being by far the most abundant. The olivines below are, for the most part, highly ferruginous varieties. The spinellids, magnetite, chromite, and picotite occur in these rocks, as do also titano-ferrite and its alteration-products. Among the accessory constituents biotite is the most abundant.

It was shown that each of the minerals of these rocks is found to undergo remarkable changes as we pass from the superficial to the central portions of these intrusive rock-masses. The most important of these changes is that for which the author proposed the name "schillerization." It consists in the development of microscopic enclosures, in the form of plates and rods, along certain planes within the crystal, giving rise to metallic reflections or a play of colour. The felspars, pyroxenes, and olivines are all found to be affected in this way when they have formed the deepest parts of these volcanic cones. In this way common augite is seen at gradually increasing depths, passing into the deep brown variety known as pseudo-hypersthene. The last-mentioned substance presents a curious "mimicry" of true hypersthene and paulite, which is the schillerized form of a ferriferous enstatite.

The Tertiary peridotites present many variations, not only in their structure, but also in their mineralogical constitution. Among them occur examples of the rocks which have received the names of dunite, picrite, and lherzolite, with some curious types composed of felspar and olivine.

Among the older peridotites of Scotland a new and very interesting type is described from near Loch Scye in Caithness. It appears to have been originally a mica-picrite, but the whole of the original minerals have been converted into paramorphs, firstly by schillerization and subsequently by amphibolization and serpentinization.

In conclusion, it was pointed out that the discrimination between the effects of the changes described as schillerization and those known as uralitization, amphibolization, serpentinization, and kaolinization is of the utmost importance, not only to the petrographer, but to the mineralogist.

2. "Boulders wedged in the Falls of the Cynfael, Ffestiniog." By T. Mellard Reade, Esq.

This paper briefly described certain phenomena of stream-denudation observed in the bed of the Cynfael, which has cut a deep channel through the Lingula Flags, the course of the channel being mainly dependent on the jointing of the rock. In one spot the upper beds at the top of the gorge have slid upon the lower along their dip, about 10° to north by east, so as to project over the stream like a corbel; and advantage has been taken of this to form a bridge by means of a slab of rock laid from the projecting mass to the top of the opposite bank. At another point several very large boulders are stuck fast in the channel, and the stream flows beneath them. The boulders could not possibly have been carried down the existing gorge, and they had not, the author believed, fallen from above. He suggested that they might have been carried down by the aid of ice, probably in the glacial period, when the stream ran in a wider channel, and that they have been polished by the action of the water.

III.—Annual General Meeting, February 20, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1884. The Council's Report further announced the awards of the various Medals and of the proceeds of the Donation Funds in the gift of the Society.

In handing the Wollaston Gold Medal to Dr. W. T. Blanford, F.R.S., for transmission to Mr. George Busk, F.R.S., F.G.S., the President addressed him as follows:—

Dr. Blanford,—The Council of the Geological Society has awarded to Mr. George Busk the Wollaston Medal in recognition of the value of his researches in more than one branch of Palæontology. Polyzoa, not only fossil but also recent, he has made peculiarly his own, and his numerous separate papers, his British Museum Catalogue, and his memoir on the Polyzoa of the Crag, have entitled him to the lasting gratitude of workers at this class of the Mulluscoida. But, perhaps as a relief to the study of these minute invertebrates, he has occupied himself, not less successfully, with the larger vertebrata, so that to him we are indebted for much information on the fauna of Post-Tertiary deposits, especially from the caves of Malta and of Brixham. Permit me, in handing you this Medal for transmission to Mr. Busk, to express my pleasure at having such a duty to discharge, and my earnest hope, in which I am sure all present will share, that restored health may enable him to continue his work in the cause of our science.

Dr. Blanford. in reply, expressed his gratification at being selected as the medium for transmitting the Wollaston Medal to Mr. Busk, whose compulsory absence he nevertheless greatly regretted, and from whom he read the following letter:—

"Dear Mr. President,—As, much to my regret and disappointment, I find myself unable to attend the Annual Meeting, I must trespass upon your kindness to express my warmest thanks and best acknowledgments for the honour you and the Council have conferred upon me in the award of the oldest of the Society's Medals, and whose receipients form such a long and distinguished roll, to which any one may indeed be proud to see his name added.

"The honour, also, in my eyes. is doubly gratifying, as being the second testimonial of the same kind, and showing the favourable estimation in which my few labours have been held by the Geological Society of London, whose continued prosperity and usefulness will always be an object of my warmest wishes.

"Believe me, yours very sincerely,
"32, Harley Street, Feb. 19, 1885. George Busk."

The President then presented the Balance of the Proceeds of the Wollaston Donation Fund to Dr. Charles Callaway, F.G.S., and addressed him as follows:—

Dr. Charles Callaway,—The Council of the Geological Society has awarded to you the balance of the proceeds of the Wollaston Donation Fund, in recognition of the value of your researches among the older British rocks. By your identification of Upper Cambrian rocks in Shropshire you have placed beyond question the antiquity of the Rhyolitic group of the Wrekin, our knowledge of which and of yet older rocks in that district you have greatly augmented. Your contributions also to the geology of Anglesey and to unravelling the stratigraphy of the Scotch Highlands have been of great value, and we look forward to the results of further researches, in aid of which I have great pleasure in placing in your hands the amount of the award. That you receive it from a fellow-labourer will, I hope, make it not the less welcome.

Dr. Callaway, in reply, said:—Mr. President,—I highly value the honour which the Council has seen fit to confer upon me, and I shall not readily forget the kind words with which you have accompanied the award. We are told that the reward of virtue is not bread; but bread is a sustainer of virtue; and in like manner, though geology is its own reward, the geologist is conscious of discouragement if the appreciation of his fellow-workers is withheld. I therefore regard this award as an effective stimulus to future exertion. It is a great pleasure to me to receive it at the hands of one who has so often been a kindly helper in working out difficult problems in lithology.

The President then handed the Murchison Medal to Dr. Henry

Woodward, F.R.S., for transmission to Dr. Ferdinand Römer, F.M.G.S., of Breslau, and addressed him as follows:—

Dr. Woodward,—The Council has awarded to Dr. Ferdinand Römer the Murchison Medal and a sum of Ten Guineas from the Donation Fund. His life-long and unwearied labours in the service of our science have long since made his name familiar to his fellow-workers. When I state that the Royal Society Catalogue, published now more than eleven years since, records the titles of 122 separate memoirs written by him, when I mention his other important works, such as that on the Chalk Formation of Texas, on the Silurian Fauna of Tennessee, on the Geology of Upper Silesia, and the "Lethæa Geognostica," I have said enough to prove that this memorial of an illustrious geologist could not well have been bestowed on a more illustrious recipient. In transmitting it to Dr. Römer, be so kind as to express our regret that the distance and the season of the year have deprived us of the pleasure of his presence on this occasion.

Dr. WOODWARD expressed his pleasure at being deputed to receive this Medal for Dr. Ferdinand Römer, from whom he had received the following letter:—

"Mr. President,—I am deeply sensible of the honour which you and the Council of the Geological Society have conferred upon me in presenting me with the Murchison Medal.

"I very much regret my inability to be present in order to receive this valuable mark of appreciation from your hands, and to express personally to you my sincere thanks for this high mark of recognition which the Society has bestowed on me.

"It is particularly gratifying to me that it is *the Murchison Medal* which you have been pleased to confer upon me, because the greater part of my scientific work has been directed to the study of those ancient rocks, the natural order of which was first recognized by the comprehensive genius of its founder, Sir Roderick Murchison.

"FERD. RÖMER."

In presenting the Balance of the Proceeds of the Murchison Geological Fund to Mr. Horace B. Woodward, F.G.S., the President addressed him as follows:—

Mr. Horace B. Woodward,—The balance of the proceeds of the Murchison Donation Fund has been awarded to you in recognition of the good service which you have already rendered to geology, especially by your work among the later deposits of the eastern counties, and to aid you in further researches. But the excellent papers which you have written, in addition to the work done by you as a member of the Geological Survey, do not constitute your only claim to our recognition. You have made use of the opportunity of your official position to promote a love of science among those who live in our eastern counties, and we are indebted to you for that admirable volume "The Geology of England and Wales," which, though in one sense a compilation, is such a one as only a skilled geologist could produce.

Mr. WOODWARD, in reply, said:—Mr. President,—I am highly honoured by this award of the Council which you have now placed in my hands A little more than twenty-one years ago I commenced geological life in the service of this Society, as Assistant in the Library and Museum at Somerset House; and I feel much indebted to that period for acquaintance with many geologists, who, for the sake of my father, extended the hand of friendship to me; and I am likewise indebted to the duties I had then to perform for a knowledge (and I may say a love) of books, which perhaps influenced the production of that volume about which you have spoken so kindly.

While labour is in most cases its own reward, it is a great satisfaction and a great encouragement to be told that one's work is useful by those who are best qualified to judge.

The PRESIDENT next presented the Lyell Medal to Professor H. G. Seeley, F.R.S., F.G.S., and addressed him as follows:—

Professor Seeley,—The Council has awarded to you the Lyell Medal and a grant of £40 in recognition of your investigations into the anatomy and classification of the Fossil Reptilia, especially the Dinosauria. Not that you have limited yourself to this field of research; your papers on *Emys* and *Psephophorus*, on *Megalornis* and British Fossil Cretaceous Birds, on *Zeuglodon*, and on remains of Mammalia from Stonesfield, prove your extensive knowledge of vertebrate palæontology, as your proficiency in invertebrate is evidenced by your earlier work, both stratigraphical and directly palæontological. Furthermore, your excellent edition of the first volume of Phillips's "Manual of Geology" indicates an exceptional familiarity with the literature of our science. Since our acquaintance first began, some twenty years since, at Cambridge, we have both had our disappointments and our successes; you, undiscouraged by the one, unelated by the other, have pushed on to your present high position in science, making no enemies, winning many friends. I trust that your future career may be even more prosperous than your past, and that this Medal may be an augury of many good gifts of fortune. You will, I know, believe me when I say that I feel an exceptional pleasure in being commissioned to place in your hands this Medal, commemorative of the great geologist whose philosophic spirit you so well appreciate, and whose memory, I know, you so greatly revere.

Professor SEELEY, in reply, said:—Mr. President,—No words of mine could adequately reflect my sense of the kind words and kind feelings to which you have given expression. I must, however, say that the honour of this award is one for which I am sincerely grateful. It is needless now to say anything in admiration of Lyell, but I may give utterance to a sense of personal obligation by saying that he has always seemed to me the greatest teacher of our science. In receiving the Medal, however, which is associated with his name, I cannot but be conscious how far short what I have done has fallen of my efforts and aspirations, and that more work than I can hope to do should have been before you in justification. With regard to the new edition of Phillips's Geology, I would say that that work, founded on the necessities of my own teaching, was undertaken to do honour to the memory of my old friend, Professor John Phillips; but it would have been more imperfectly done without the important help which I found in your own writings. I shall find in this award a stimulus to future work, which I hope may give results more worthy of recognition than the work to which you have referred.

The PRESIDENT then handed the Balance of the Proceeds of the Lyell Geological Fund to Mr. J. J. H. Teall, F.G.S., for transmission to Mr. A. J. Jukes-Browne, F.G.S., and addressed him as follows:—

Mr. Teall,—The balance of the Lyell Donation Fund has been awarded to Mr. A. J. Jukes-Browne in recognition of the excellent work that he has done on the Cretaceous formation and on Glacial geology, and to aid him in further researches. His papers on the Cambridge Greensand cleared up many difficulties connected with that interesting formation; and in his Segdwick prize essay on the Post-tertiary deposits of Cambridgeshire he commenced those investigations which have since brought us more than one valuable contribution on glacial and later deposits. You can tell him that his old college tutor feels a little pardonable pride and much real pleasure in being the instrument of placing this award in your hands for transmission to him.

Mr. TEALL, in reply, expressed his regret that Mr. Jukes-Browne was prevented by domestic anxieties from being present, and read an extract from a letter received from him. In this Mr. Jukes-Browne said:—

"That my labours in the field of geology should have been thought worthy of such recognition is most gratifying and encouraging, and I am especially pleased that the award should come from the Lyell Donation Fund; for among all the departed masters of our science there is no one for whom I feel greater respect than for Sir Charles Lyell, or whose mental attitude I more desire to imitate. To be entered therefore on the roll of those who are deemed worthy of receiving the award instituted by Sir Charles Lyell will always be a source of extreme pleasure.

"I need hardly assure the Council and Fellows of the Society that such strength and powers as I possess will be spent in the service of geological science, because that must be so as long as I am connected with the Geological Survey; but this mark of their approbation will stimulate me in the performance of such extra official work as I am able to accomplish, and I only wish that my health would allow me to do more."

In presenting the Bigsby Gold Medal to Professor Renard, of Brussels, the PRESIDENT addressed him as follows:—

Professor Renard,—When to a familiarity with geology in the field and a love of nature are united the skill of a finished chemist and the experience of a practised worker with the microscope, the results cannot fail to be of the utmost importance to our science. These qualifications, rarely united in any one man, are in yourself combined with an untiring industry and a love of science for its own sake. Thus we are indebted to you for many important contributions to our knowledge in geology. Your early memoir "Sur les Roches Plutoniennes de la Belgique et de l'Ardenne Française," written in conjunction with M. de la Vallée Poussin, will long be classic; your papers on various subjects connected with the Carboniferous Limestone, on the coticule, the phyllites, and other altered rocks of Belgium, and on the deep-sea deposits are too well known to need more than mention, and in recognition of these the Council has awarded you the Bigsby Medal.

In placing it in your hands may I be allowed to express for myself and others the hope that it will be always a pleasant *souvenir* of your many friends on this side of the Channel, some of whom, myself included, will not soon forget the pleasant and, to us, most profitable days spent under your guidance in geological studies by the limestone cliffs of the winding Meuse and the wooded crags of the Ardennes.

Professor RENARD, in reply, said:—Mr. President and Gentlemen,—In rising to express my thanks to you I labour under a great disadvantage; it would have greatly conduced to my comfort to speak in my own language, but the magnitude of the honour you have conferred upon me makes me feel that I must at all events attempt to address you in your tongue.

To hold the Medal which you have awarded to me is no common distinction. I cannot but feel that you are rating my merits more highly than they deserve. Though not an Englishman, I never feel myself a stranger in your country. I have visited it so often, and had so much friendly intercourse with your scientific men, that I am not altogether without misgiving that your Council may, unconsciously to themselves, have supplemented my deficiencies as a geologist by their personal friendliness towards myself. The particular line of study to which I have devoted myself is essentially English. Your countryman, Sorby, was the pioneer of microscopic lithology, and I have only followed the track which he was the first to open up.

In conclusion, allow me to say that though sensible of my own deficiencies, I am confident that your good opinion will stimulate me to fresh exertions. I shall pursue my scientific work with renewed energy, and it will be my constant endeavour to show you that your confidence was not altogether misplaced, and make myself in the future worthy of the great honour you have conferred upon me.

The PRESIDENT then read his Anniversary Address, in which, after giving obituary notices of some of the Members lost by the Society during the year 1884, he referred to the principal contributions to geological knowledge which have been made during the past year, both in the publications of the Society and elsewhere in Britain, concluding with a notice of the new views which have been adopted with regard to the structure of the Western Highlands, and a brief history of the steps by which they have been arrived at. The concluding portion of the address was devoted to a discussion of the principles of nomenclature which should be followed in petrology, with remarks on the classification of igneous rocks, and on the significance of certain structures, especially the more minute.

The ballot for the Council and Officers was taken, and the following duly elected for the ensuing year:—*President:* Prof. T. G. Bonney, D.Sc., LL.D., F.R.S. *Vice-Presidents:* W. Carruthers, Esq., F.R.S; John Evans, D.C.L., LL.D., F.R.S.; J. W. Hulke, Esq., F.R.S.; and J. A. Phillips, Esq., F.R.S. *Secretaries:* W. T. Blanford, LL.D., F.R.S., and Prof. J. W. Judd, F.R.S. *Foreign Secretary:* Warrington W. Smyth, Esq., M.A., F.R.S. *Treasurer:* Prof. T. Wiltshire, M.A., F.L.S. *Council:* H. Bauerman, Esq.; W. T. Blanford, LL.D., F.R.S.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; W. Carruthers, Esq., F.R.S.; Prof. W. Boyd Dawkins, M.A., F.R.S.; John Evans, D.C.L., LL.D., F.R.S.; A. Geikie, LL.D., F.R.S.; Henry Hicks, M.D.; Rev. Edwin Hill, M.A.; G. J. Hinde, Ph.D.; John Hopkinson, Esq.; W. H. Hudleston, Esq., M.A., F.R.S.; J. W. Hulke, Esq., F.R.S.; Prof. T. Rupert Jones, F.R.S.; Prof. J. W. Judd, F.R.S.; J. E. Marr, Esq., M.A.; J. A. Phillips, Esq., F.R.S.; Prof.

J. Prestwich, M.A., F.R.S ; Warrington W. Smyth, Esq., M.A., F.R.S.; J. J. H. Teall, Esq., M.A.; W. Topley, Esq.; Prof. T. Wiltshire, M.A., F.L.S.; Rev. H. H. Winwood, M.A.; Henry Woodward, LL.D., F.R.S.

IV.—February 25, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Dredged Skull of *Ovibos moschatus.*" By Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.

As some doubts have been expressed as to whether a skull of *Ovibos moschatus*, described by the author in a previous communication to the Society had been derived from the Forest bed, he first quoted the opinion of Mr. Clement Reid, that that specimen really came from the bed in question, and then proceeded to describe a second imperfect skull of the same animal in the University Museum of Zoology and Comparative Anatomy at Cambridge. The trace of red sandy matrix still remaining and the impregnation with iron peroxide showed that this also had been derived from the Forest bed, whilst the presence of marine Polyzoa on the surface and in cracks was considered to prove that the fragments in question had lain at the bottom of the sea, and the sharpness of the angles forbade the supposition that it had been rolled on a beach. The writer inferred that the skull had been dredged, and that it had been originally derived from cliffs near the Dogger Bank before the coast-line had been cut back to its present position. The fragments consisted of the coronal and frontal portions of the skull with the horncores and right orbit. It seems of unusual thickness, and the author briefly describes its leading peculiarities and measurements.

2. "On Fulgurite from Mont Blanc." By Frank Rutley, Esq., F.G.S.

The specimens described in this paper were collected by Mr. J. Eccles on the Dom du Gouté, about 14,000 feet above the sea-level. The rock, which has been fused by lightning, is a hornblendic gneiss. The fusion in the specimens examined is quite superficial. The hornblende has been converted into a dark, and the felspar into a white, glass, which, as a rule, remain distinct. The fulgurite in some cases consists of small spheres of glass, mostly of dark colour, which, in one instance, appear to have been spurted over the surface of the rock while in a state of fusion. The fulgurite glass is quite free from microliths, and shows only gas-bubbles and inclosures of glass, the latter usually containing nests of such bubbles. In conclusion, a comparison was made between this fulgurite and the Bouteillenstein or puseudo-chrysolite of Bohemia, which is now regarded by Makowsky and others as an artificially formed glass.

3. "On Brecciated Porfido-rosso-antico." By Frank Rutley, Esq., F.G.S.

The variety of this well-known hornblende-porphyrite here described shows a distinctly brecciated structure when examined in thin section under the microscope. The fragments sometimes appear to fit together, at others they are more or less widely seperated, so that the section at first sight presents almost the aspect of a tuff.

Careful examination shows that this brecciated structure is due merely to the rock having been crushed and the fragments connected *in situ* by siliceous infiltrations. Delesse's observations upon the varieties of the rock were discussed. A few additional remarks were also made upon the mineral constitution of the specimens described.

4. "Fossil Chilostomatous Bryozoa from Aldinga and the River-Murray Cliffs, South Australia." By Arthur William Waters, Esq., F.G.S.

The 73 fossils described in the present paper were collected by Professor Ralph Tate, and, with a few exceptions, are from Aldinga and the River-Murray Cliffs, Australia.

This collection again furnishes interesting cases of species growing in both the Eschara and the Lepralia form; but the chief interest is in a number of specimens which grow in a "cupulata" manner, thus in the mode of growth resembling *Lunulites.* Attention was again called to the fact that though the shape and nature of the zoœcial avicularia (onychocellaria) are characters of the greatest value, yet their presence or absence cannot be made a specific distinction, as there are a large number of cases where specimens are found with none or only a few such avicularia, whereas on other specimens of the same species, collected under similar circumstances, they may occur abundantly over the whole colony, or in parts of the colony, in large numbers.

In the "Challenger" Report, Mr. Busk refers to a slender process rising from the middle of the base of the avicularian mandible, and names it "columella." This he considers only occurs in one division of the *Celleporæ*, and in this division only in those belonging to the southern hemisphere. This was shown to be by no means the case, as it is found in the mandibles of *Celleporæ sardonica* from the Mediterranean, in two other common Mediterranean *Celleporæ*, etc. In many species there is a denticle in this position rising from the calcareous bar which divides the avicularium. This denticle occurs in various genera and species, and may often be found a useful specific character when examining fossils.

Out of the 220 species now described in this series of papers, just about one-half are now known living.

The species noticed in this paper are 73 in number, referred by the author to the genera *Cellaria*, *Membranipora*, *Micropora*, *Monoporella*, *Steganoporella*, *Cribrilina*, *Mucronella*, *Microporella*, *Lunulites*, *Porina*, *Lepralia*, *Smittia*, *Schizoporella*, *Mastigophora*, *Retepora*, *Rhynchopora*, *Cellepora*, *Lekythopora* and *Selenaria*. Five species are described as new, namely, *Microporella pocilliformis*, *Lepralia confinita*, *Cellepora biradiata*, *Schizoporella protensa*, and *Membranipora temporaria*.

CORRESPONDENCE.

FAULTS.

Sir,—If Professor Blake will kindly look at the Geological Magazine, Vol. III., p. 148 and Plate IX. Fig. 9 (1866), he will see a notice of some faults in Malta that do not penetrate the limestone lying below the bed in which they occur. These faults are thus accounted for—"I suppose that the rock, being already jointed, was pressed down before it was quite hard by the weight of the superincumbent strata, and the pressure on each fragment being proportional to the area of the upper surface, those fragments which had the largest upper surface in proportion to their bulk were more compressed than the others, thus forming faults. The broken state of many of the fossils, particularly the *Echini*, in this bed is a proof that it has undergone considerable compression. I may, perhaps, here mention that I consider that all cases of 'reversed faults' will be found to have been caused by lateral pressure." As this was written nearly twenty years ago, I hope you will not mind reproducing it. F. W. Hutton.

Christchurch, N.Z.

FULLER'S EARTH.

Sir,—I shall feel obliged if you will give notice to the accompanying facts connected with the detergent properties of the fuller's earth,—I mean with regard to its use as an agent in clarifying water, a reference to which appeared in the Geol. Mag. for February last. These strike me as being the more curious, because, as far as I can learn, they are but little known.

In the fen districts of Cambridgeshire and Lincoln, where the people are entirely dependent upon the discoloured drainage off the peat for their water supply, *fuller's earth*, brought round by dealers, is used to purify the water, rendering it colourless and pleasant to the taste. The method adopted is somewhat after the old fashion in country districts, of placing perforated trays or *letches*, as they were called, containing wood or other ashes, over vessels put to catch the rain.[1]

To test the efficacy of fuller's earth as a filtering medium, I have experimented with it upon the mineral water of Flitwick, which is the colour of dark sherry and so powerfully impregnated with iron[2] as to act upon the palate as alum, with the result that it was made nearly colourless and its strength reduced by one-half.

Muddy water too, if filtered through it, becomes clear and free of sediment. Springs issuing from beneath the fuller's earth are remarkably limpid and free from earthy impregnations. The interstratification in the rusty brown sands of the white stone (detailed sections of these beds will be given in Survey Memoir on Sheet 46), on which the fuller's earth rests, may be due to the bleaching properties of the fuller's earth with which it is in contact. The Flitwick water comes off peat lying in a valley cut down through the Greensands to the underlying Oxford. There is an enormous quantity of iron in the water (as the analysis shows), encrusting everything over which it flows, and a tufaceous-looking deposit of bog iron ore is being formed of some extent and thickness. A. G. Cameron,

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[1] Dr. Thos. Stevenson, Guy's Hospital, has kindly written to say— · · · "fuller's earth is an agent which I conceive would be very useful for the purpose, it is a substance which would clarify, remove organic matter in solution, and also soften by carrying down chalk.

[2] Professor W. White's analysis gives 144·00 grains per gallon, oxide and carbonate of iron, "a most extraordinary amount and far exceeding the most noted chalybeate springs in the world." E. W. Lewis, upon "The Geology of Leighton and Neighbourhood."

Bedford. H. M. Geological Survey.

OBITUARY.

JOHN FRANCIS CAMPBELL, F.G.S., &c.,

(iain ileach), of islay.

John Francis Campbell, of Islay, the bearer of a name well known among geologists some years ago, was born in Edinburgh on the 29th December, 1821. He had high family connections on the side of both parents—his father being cousin to the present Duke of Argyll, and his mother, who died while he was still a youth, being the Lady Ellinor Charteris, daughter of Francis, seventh Earl of Wemyss. By birth he was heir to a large patrimonial estate. This inheritance was, however, lost to him through adverse circumstances shortly after he came of age; and the magnanimous spirit in which through life he bore this reverse of fortune gained him the abiding esteem of the large circle of friends whose regard his generosity of heart and many attractive qualities must in any case have secured.

When, on the death of his father, who several years before had contracted a second marriage, he found himself at a comparatively early age the head of the family, he did everything in his power to promote the welfare of his step-mother and her children. In the year 1855 he joined them in their newly-adopted home at Niddry Lodge, Campden Hill; and, laying aside the study of the law which he had for some years previously pursued, he found occupation successively as Private Secretary to his chief, the Duke of Argyll; Secretary to the Board of Health, to the Mines Commission, and to the Lighthouse Commission,—the two latter employments stimulating him in those studies of Geology and Solar Physics which engaged his attention and effort even in the last years of his life. During the years 1861–1880 inclusive he held in succession two posts in the Queen's Household. Having withdrawn from the Court at the latter date, he afterwards occupied himself till the close of his life with scientific study, travelling, and the social life of his home.

His many journeys in former vacations had taken him several times into Iceland and Scandinavia. On one occasion (1873–74) he passed from Archangel through Russia to the Caucasus, returning by Constantinople and Southern Europe. In 1874–75 he made a voyage round the world, during which he visited Japan, China, Java, and Ceylon, etc.; in 1876–7 he spent some months at various stations of India, and witnessed at Delhi the ceremony of proclaiming the Queen Empress; during 1878 to 1880 and 1881 he visited Syria and Palestine, and twice resided in Egypt. In all these wanderings his instinctive powers as a practical linguist were very valuable to him; his ready skill as a draughtsman not less so.

His chief published works are: "Popular Tales of the West Highlands" (in four vols.), a work for which his fluent command of the Scotch Gaelic and his enthusiastic memories of his boyhood's island home eminently fitted him; "Leabhar na Feinne," genuine Texts of Gaelic Folk-lore, too recondite for any but Celtic scholars; "Frost and Fire," a book in which incidents of travel and matters of scientific observation, geological and otherwise, are mingled in an original fashion; "My Circular Notes," an entertaining account of his journey round the world; "Something from the Gold-Diggings of Sutherland," specially geological. Among his minor writings are articles on "Glaciation," read before the Geological Society, and published in their Quarterly Journal.[1]

His mind was acute, ingenious, and indefatigably active; but he had never subjected it to received methods of scientific training, and he was more disposed towards detecting the weak point in the arguments and inferences of other thinkers than willing to adopt them. His mental stores, whether gleaned in the field of Folk-lore and Myth or in that of experimental Science, were original, not derived from other workers. This circumstance gave a special kind of interest to his observations and opinions, even where the listener might not accept his conclusions.

His invention of the "heliometer,"[2] an instrument in use at Greenwich, and which was mentioned with honour by Professor Balfour Stewart at the meeting of the British Association in 1883, is probably the only distinction that will survive him. But he was not only entirely uninfluenced by any desires after a lucrative result of such work as he did, but comparatively indifferent even to the fame which it might have brought him. He loved knowledge for its own sake; his desire was for "more light." His best praise will dwell in the hearts of his many friends; all who knew what his own heart was—those who have shared his refined and genial hospitality, or benefited by his ready generosity, counsel, and help—will never lose their warm remembrance of his truly noble spirit and kindly bearing, and will apply to him with added emphasis the well-known lines—

> Who broke no promise, served no private end,
> Who knew no enemy, and lost no friend.[3]

He died at Cannes, February 17th, 1885.

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[1] Another work by Mr. Campbell, "A short American Tramp," contains many valuable observations on Climate (see GEOL. MAG. 1868, Vol. V. p. 299).

[2] See List of Instruments set forth by the Meteorological Society.

[3] Pope. The original second line is,
"Who served no patron, etc."

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No. V.—MAY, 1885.

ORIGINAL ARTICLES.

I.—The Inland Seas and Salt-Lakes of the Glacial Period.

By T. F. Jamieson, F.G.S.

IN certain parts of the world, where the climate is very dry, we find examples of large salt lakes out of which no water ever flows towards the ocean. These lakes are fed by the rains and streams of the surrounding regions, but the evaporation from the surface is so great that it dries up the water as fast as it comes in, so that the lake remains stationary—the influx of water and the amount evaporated just balancing one another.

The Caspian Sea is the largest example of this nature; there are also the Sea of Aral, the Balkash, the Dead Sea, and many others of lesser note.

It is evident, however, that, should any change take place in the climatic condition of the surrounding regions, these lakes would be influenced thereby.

If it got drier, the water would evaporate faster than it came in, and the lake would diminish in size until an equilibrium was again established, or it might even be dried up altogether and converted into a plain of salt, as has been the case with many small lakes. On the other hand, if the climate grew wetter, the lake would rise in level and, were the humidity to increase enough, would go on enlarging until the water filled the basin; it would then send out a river over the lowest part of the border, and be converted into an ordinary fresh-water lake.

In these salt lakes, therefore, Nature has furnished us with a delicate means of detecting the secular changes that take place in the atmospheric moisture of the surrounding regions, and if properly studied, they ought to afford us considerable help in dealing with the history of later geological times.

A good many years ago I ventured to speculate upon the influence which the Glacial period would have upon these lakes, and in a paper upon a kindred topic published in the Quarterly Journal of the Geological Society (1863, vol. xix. p. 258), I expressed myself as follows:

"More important effects, however, than these must have followed from the refrigeration of the climate of Central Asia during the Glacial period, and which I have not seen noticed. The great basin of the continental streams, larger than the area of Europe, is remarkable for its inland lakes from whence no streams ever reach the ocean, owing to the great heat drying up the water. Now this heat and dryness being much lessened during the Glacial period, there must have resulted a much smaller evaporation, which would no longer balance the inflow. These lakes, therefore, would swell and rise in level, and thus the Caspian, the Aral, and the Balkash might have spread until they became more or less connected into a wide inland sea, discharging its surplus into the Euxine or along that depression skirting the east flank of the Ural noticed by Humboldt. This rise of the Caspian, damming back the waters of the Volga and other streams, would occasion large deposits of alluvial matter over the surrounding flat regions, and account for many of the fresh-water beds that occur there. The other great Asiatic depression to the north of the Kuenlun Mountains would likewise be filled with water, and it is somewhat curious to find that the Chinese have a tradition that Lake Lhop once drained into the Hoang Ho. The sandy deserts of Central Asia are probably the dried-up beds of these inland seas."

Since the time this passage was written, many interesting facts have been discovered which tend to support the opinion I have there expressed. Some of these I now proceed to notice.

The Great Salt Lake Basin of North America.

In the western dominions of the United States, between the Sierra Nevada and the Rocky Mountains, there is a large extent of territory with a very dry climate. Much of the surface is occupied by deserts, and there are many salt lakes, of which the most notable is the Utah Lake in the country of the Mormons.

During the survey of this region by the geologists of the United States evidence has been got that this lake had formerly attained a much greater size, and must have been a sheet of water as large as Lake Huron. The old shore-lines can still be traced with the greatest distinctness along the hill-sides up to a height of more than 900 feet above the present level of the lake, and its whole extent has been mapped out by Mr. G. K. Gilbert, one of the chiefs of the Survey, who has made it the subject of special study. He has been able to detect several phases in its history and has given it the name of Lake Bonneville. It appears there have been two periods of high water separated by an intervening dry period during which the lake sank even below its present level, and in fact disappeared altogether. Mr. Powell, Director of the Survey, sums up the history as follows:—

"First, the waters were low, occupying, as Great Salt Lake now does, only a limited portion of the bottom of the basin. Then they gradually rose and spread, forming an inland sea nearly equalling Lake Huron in extent, with a maximum depth of one thousand feet. Then the waters fell and the lake not merely dwindled in size but absolutely disappeared, leaving a plain even more desolate than the Great Salt Lake desert to-day. Then they again rose, surpassing even their former height, and eventually overflowed the basin at its northern edge, sending a tributary stream to the Columbia River. And, last, there was a second recession, and the water shrunk away

—until now only Great Salt Lake and two smaller lakes remain. Translated into terms of climate, these changes imply that there were two epochs of excessive moisture—or else of excessive cold—separated by an interval of superlative dryness and preceded by a climatic period comparable with the present. The first epoch of humidity was by far the longer, and the second, which caused the overflow of the waters, the more intense" (Second Annual Report of the U.S. Geological Survey, Washington, 1882, p. xvii).

In the same region there are traces of another large lake, which is described by Mr. Clarence King in vol. i. of his work on the Geology of the 40th Parallel. He calls it Lake Lahontan, and it has been made the subject of further investigation by Mr. I. C. Russell. The progress of events as traced out by these geologists harmonizes very closely with what has been found by Gilbert in regard to Lake Bonneville, namely, two periods of high-water separated by an interval of great dryness. Of these two periods of humidity the first continued longest, but the second produced the greatest rise of the lake. The supposed connection of these events with the Glacial epoch is thus expressed by Mr. King:—

"The Quaternary lakes of the Great Basin (L. Bonneville and L. Lahontan) are of extreme importance in showing one thing—that the two Glacial ages, whatever may have been their temperature conditions, were in themselves each distinctly an age of moisture, and that the Inter-Glacial period was one of intense dryness, equal in aridity to the present epoch." "We are warranted in assuming for the first age of humidity of the lake an enormously long continuance as compared with the second. The first long-continued period of humidity is probably to be directly correlated with the earliest and greatest glacier period and the second period of humidity with the later Reindeer Glacier Period" (Geology of the 40th Parallel, vol. i. p. 524).

From these quotations it will be seen that the American geologists have arrived at the same result for the Great Salt Lake Basin as I supposed would occur in the Aralo-Caspian region, namely, a great rise of the waters coincident with the occurrence of a Glacial period.

Gilbert thinks there have been only two great rises of the lake waters: "There is abundant evidence," he says, "that each great rise and fall recorded by the shore-lines of Lake Bonneville was interrupted by intervals of reverse motion, the rising waters occasionally hesitating and sinking for a time, and the falling water occasionally oscillating upwards. It may be asserted with confidence, however, that the history includes but two great waves. If the water had many times, instead of twice only, risen to the upper levels of its range, the tell-tale sediments could not have failed to record the intervening subsidences." And he further says that if the student "correlates the second humid wave with the Reindeer epoch of English geologists, he will be surprised to find that in Utah the climate was more severe than during the first maximum, although maintained for a shorter period" (Second Annual Report of the U.S. Geol. Survey, p. 187).

The Dead Sea.

In 1865 M. Lartet announced that he had found evidence which led him to conclude that towards the end of the Tertiary, or at the commencement of the Quaternary period, the surface of the Dead Sea must have had an elevation of more than a hundred mètres above its present level, and that it had deposited up to that height stratified beds of marl full of gypsum and salt, showing that the lake was even then extremely salt. He failed, however, to discover any vestige of organic remains in these marl beds, which extend a considerable way north and south of the present extremities of the lake. Alluding to Hooker's discovery of glacier moraines on the Lebanon, Lartet infers that a climate which clothed these mountains with permanent snow and ice would have lessened evaporation, and led to an increase of the waters of the Dead Sea and other inland lakes of Asia somewhat as I had suggested.[1]

More recently Canon Tristram has noticed indications which lead him to believe that the Dead Sea had attained a much higher level than that mentioned by Lartet. Doubtless it must have gone through many phases of rise and fall, but its history will require to be more fully worked out before we can arrive at satisfactory conclusions on the subject.

The Aralo-Caspian Basin.

The same may be said of this great depression. There is ample evidence that the waters here had formerly a much wider extension, but the exact time, or times, when this occurred—although geologically recent—has yet to be determined. Dr. S. P. Woodward, in his Manual of the Mollusca, says the Aralo-Caspian limestone indicates the former presence of a great inland sea—larger than the Mediterranean—at a time previous to that of the Mammoth and the Siberian Rhinoceros. This steppe-limestone rises to a level of 200 or 300 feet above the present level of the Caspian.

The fact of the waters of the Caspian and Aral being only brackish, and by no means very salt, leads me to think that the basin has not been a close one for a *very* long period. General von Helmersen found well-preserved specimens of two kinds of shells, viz. *Cardium edule* and *Dreissena polymorpha*, in the sands of the desert of Karakum. Both these species still live in the Caspian. And Helmersen expresses his belief that the entire country from the Aral on to the sandy deserts of Akkum is an old sea-bottom (Quart. Journ. Geol. Soc. 1869, vol. xxv. Memoirs, p. 8).

The present surface of the Caspian is 84 feet below that of the Black Sea, and according to Major Wood a rise of 220 feet would cause the waters of the Caspian to overflow the watershed of the Tobolsk, a tributary of the Obi.

According to the same authority, a rise of 23 feet in the waters of the Black Sea would cause it to overflow into the Caspian by the line of the Manytsch.

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[1] Bulletin of the Geol. Soc. of France, second series, vol. 22, p. 420.

From these figures it appears that if the level of the Caspian were to rise (84 + 23) 107 feet, its waters would find their way westward into the Black Sea, and if the outlet in that direction were blocked so as to permit the surface of the Caspian to rise 220 feet, the waters would escape northward into the Tobolsk and down the valley of the Obi into the Arctic Ocean. Now the Caspian at present contains Seals, Fishes, Crustacea, and Mollusca, some of which are either identical with, or very closely resemble, those of the Arctic Sea. The Seal which inhabits its waters (*Phoca Caspica*) is so like the common *P. vitulina* that some naturalists consider it to be a mere variety of that species. There are also the Beluga, the Sturgeon, the Herring, the Sterlet, and the Salmon, some of which are species that go up rivers from the sea. Among the Crustacea is *Idothea entomon*, found in the Kara Sea, near the mouth of the Obi, and *Mysis relicta*, another northern species. So that there *are* grounds for supposing that some communication may have formerly existed by way of the Obi with the Arctic Ocean. No doubt the waters of the Aralo-Caspian basin have undergone many changes of level. Some of the mollusca which still live there, such as the *Cardium* and *Dreissena*, appear to be descendants of species found in the Congerian beds of that region, which go back to Miocene times.

The Pangong Lake.

All the inland waters and salt lakes of Persia and Central Asia show indications of a former greater extension. The Pangong Lake (lat. 33½°, long. 79°) in Ladak may be here quoted as an interesting example. It is one of the highest-lying lakes in the world, situate on the watershed between Cashmere and Tibet. It is a salt lake, one hundred miles long, with no outlet. Dr. Henderson found old beaches up to 70 feet above the present surface of the water, containing spiculæ of sponges and freshwater shells of the genus *Lymnæa*, showing that the lake had formerly been much larger and less salt. There is also evidence that a large stream issued from it and flowed down the adjoining valley into the river Shyock. Old lacustrine deposits are very extensive in Ladak, and extend up to 15,000 feet above the sea. Traces of ancient glaciers are likewise seen in the shape of enormous terminal moraines, and this in a locality where there is now scarcely any snow. (See Dr. Henderson's interesting book, "From Lahore to Yarkand," 1873).

This association of lacustrine beds and old moraines serves to connect the phenomena with the Glacial period.

The Mediterranean Basin.

At Gibraltar indications have been found of several movements of upheaval and depression in later geological times, whilst the occurrence of fossil remains of several African animals in the caves and rock fissures of that locality, as also in Spain, has led to the belief that a land communication must have existed between Spain and the opposite coast of Africa during some part of the Quaternary period.[1]

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[1] See Falconer and Busk, Quart. Journ. Geol. Soc. vol. xxi. p. 364; also Ramsay and Geikie, *ib.* vol. xxxiv. p. 535, and the papers there cited.

A submarine ridge extends across from Cape Spartel to Trafalgar,[1] over which the deepest soundings do not excee fathoms. Now it is computed that the amount of evaporatio the whole drainage area of the Mediterranean basin is fully that of the precipitation—the average rainfall being about 30 i in the year, while the evaporation is considered to exceed 60 in so that, were it not for the strong current which sets into it fro Atlantic, the level of this inland sea could not be maintained present height. The excess of evaporation is further shown fact that the waters of the Mediterranean are salter than th the Atlantic.

If therefore the communication between the two seas were by a barrier of dry land extending across the Straits, the Mediterranean would sink gradually in level until an equili was established between the loss and the supply.

We have seen that in the history of the salt lakes of America the two periods of high-water were separated by great dryness, during which the Utah lake was dried up altog and there is much evidence to prove that in Europe the period was broken up by at least one long interval of w temperature, during which the Hippopotamus and other A animals found their way north as far as England. In Ge also they have recently got further evidence that a dry c supervened in Central Europe after the first stage of the period, the remains of several 'steppe' animals having bee covered by Dr. Nehring[3] in an intermediate part of the drift while many of the Loess deposits have been shown by Rich to be accumulations formed by dry winds, such as occur only climatic conditions of great aridity.[4]

Supposing, then, the Atlantic to be shut out by the convers the Straits of Gibraltar into dry land, and the climate to be s to induce a strong evaporation from the surface of the M ranean, its waters would of necessity sink in level, and it wou converted into a chain of lakes. The submarine ridge which between Sicily and Tunis would be laid dry, and another would thus be opened up for the passage of the African a into Europe. And here it is interesting to note that remains African Elephant have been found in the caves of Sicily along those of the Hyæna and Hippopotamus. In Malta also the re a mammalian fauna are got which can be accounted for only o supposition that this small island was formerly of much g extent and connected probably with the mainland.

Admiral Spratt says the abundance of the remains of potamus that have accumulated in the caves of Malta lying the bold coast-line of that island, as also in the caverns ov north shore of Sicily, seems to point to the necessary existe large areas of land and fresh-water, and he thought the whole of the evidence pointed to a "fresh-water or perhaps brackish condition of the entire Mediterranean area at that time," "especially as we find these ossiferous caverns mainly upon the margin of its steepest coast-line."[1]

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[1] Lyell's Principles, 11th ed. vol. i. p. 497.

[2] Encycl. Britannica, 9th ed. art. "Mediterranean."

[3] See GEOLOGICAL MAGAZINE for 1879, p. 176, and *Ibid.* for Feb. 1883, p

[4] Credner, Elemente der Geologie, 5th ed. p. 272.

So abundant were the bones and teeth of Hippopotamus in the Sicilian caves that ship-loads of them were exported for commercial purposes, and, to quote the words of Dr. Falconer, "Countless Hippopotami have been met with in Sicily — literally tens of thousands of two species" (*Memoirs*, vol. ii. p. 552).

No one, I think, can read the description which Dr. Leith Adams gives of his explorations in Malta without being convinced that the aspect of this island must have been widely different at the time when it was a haunt of Elephants, Hippopotami, and fresh-water Turtles. (See his book, *Notes of a Naturalist in the Nile Valley and Malta*, 1870.)

As the neighbourhood of Sicily has long been the seat of volcanic disturbance and of movements of the ground, it is quite conceivable that, apart from the changes going on at Gibraltar, a land communication might have been established between Italy and Africa during part of the Quaternary period, for submarine ridges at no very great depth stretch across that part of the Mediterranean. This would isolate the eastern part of the basin and allow evaporation to have its effect there, even although the western area was open to the Atlantic.

The drying up of the Mediterranean would have the effect of uniting most of the islands with the mainland, and thus explain how the animals and plants got into them. In what other way can we account for Foxes being found in Minorca; Hares, Martens, Deer, Foxes, etc., in Corsica and Sardinia; and such like facts? This fall in level of the Mediterranean would cause all the rivers entering it to cut deeply through their old deltas, and to form new ones at a much lower level. The Black Sea would also be lowered and converted into a freshwater lake drained by a large river rushing through the Bosphorus and Dardanelles.

Messrs. Ramsay and Geikie in their paper on Gibraltar, at p. 538, speculate on what would be "the influence of the physical conditions that would obtain upon a general elevation of the Mediterranean area for 1500 feet or thereabout," and go on to say, "We must remember that such a degree of elevation would convert the Mediterranean into two salt lakes, the eastern one of which would receive the drainage of several great rivers, while the western basin would be supplied by no river larger than the Rhone. In this latter basin, therefore, evaporation being much greater than the influx of fresh-water, the level of the inland sea would be gradually lowered and the area of land increased, so that in course of time the Western lake might be reduced to very moderate proportions."

Supposing the Western lake to have been thus the lower one, which I think is very probable, the effect would have been to cause the other to drain into it. This would wash the salt out of the Eastern lake and freshen its waters—that is to say, if it *had* an overflow. From Admiral Spratt's chart,[1] it appears there is a deepish narrow channel across the submarine ridges between Sicily and Africa, which may perhaps indicate the course of the river that flowed out of the Eastern lake. But as the evaporation would be considerably stronger in the eastern area, seeing that it lies farther inland and more to the south, possibly no overflow would take place. Not many years ago it was often stated that the Sahara desert was occupied by the sea during the Quaternary period. Had this been the case it would of course have tended to render the air in its vicinity more humid, and have lessened evaporation over the adjoining parts of the Mediterranean; but this notion of a late submergence of the Sahara has not been sustained by more recent investigation, and it is now believed to have been dry land. Karl Zittel, in his "Contributions to the Geology and Palæontology of the Libyan Desert" (Cassel, 1883), says that during the Quaternary period (*Diluvial Zeit*) the Sahara, as well as a portion of the southern and eastern area of the Mediterranean, was dry land.[2] The desert sand results from the decomposition of the sandstone which forms the prevailing rock throughout the Central and Southern Sahara, and its distribution and heaping up into dunes have been effected by the wind. Among the Quaternary deposits may be mentioned beds of calcareous tufa in the oasis of Chargeh, containing reeds and leaves of *Quercus ilex*, a tree which now grows in Southern France and Corsica.

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[1] Quart. Journ. of the Geol. Soc. vol. xxxiii. p. 294.

If the eastern portion of the Mediterranean—the Levant—had been isolated by the elevation of a ridge of dry land connecting Italy with Tunis, and the evaporation not been sufficient to keep down the water in that basin, then it would have risen until it escaped over the low ground at the Isthmus of Suez into the Red Sea. But I am not aware of any evidence, geological or otherwise, to show whether this has occurred during the Quaternary period.

The drying up of the Mediterranean would re-act upon the climate of Southern and Central Europe and cause *it* to be drier. so that less water would flow from thence into the basin, and this would tend to lower the inland sea still more.

Prof. Boyd-Dawkins, in his interesting book on "Cave Hunting," speculates on a former elevation of the Mediterranean basin—greater even than that suggested by Ramsay and Geikie—as being necessary to account for certain facts he mentions. But an upheaval of the whole area of this large sea seems too violent a hypothesis, and is unnecessary. All we want is to shut out the Atlantic, and evaporation will then do the rest that is required by drying up the water.

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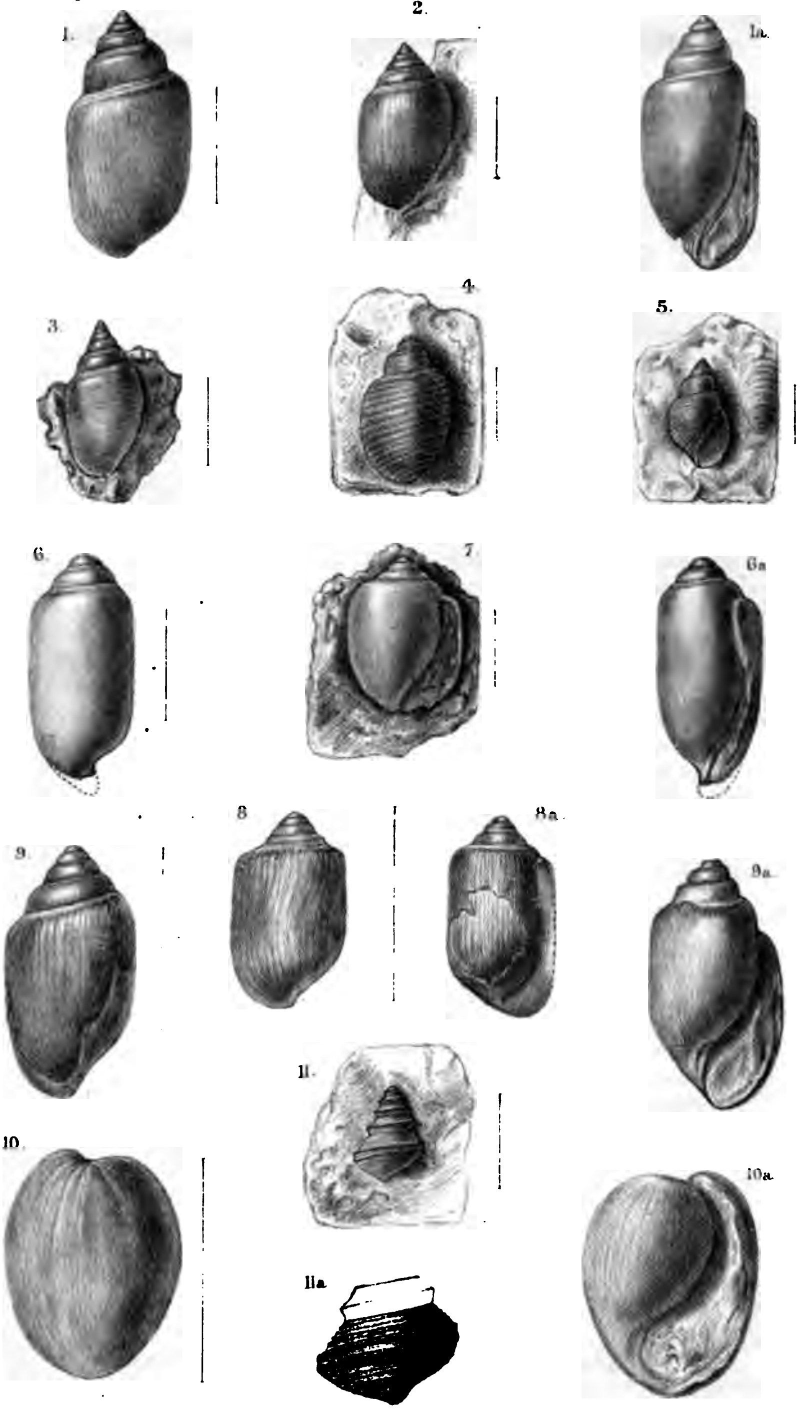
[1] Quart. Journ. Geol. Soc. vol. xxiii. p. 293.

[2] See also A. Pomel, Bull. Geol. Soc. of France, for 4th Feb. 1878, 3rd ser. vol. vi. p. 223, and M. Tournouer, *ib.* p. 619.

ELLON, ABERDEENSHIRE.



el et lith. Mintern Bros. imp.

Lower Oolite Gasteropoda, Yorkshire.

II.—CONTRIBUTIONS TO THE PALÆONTOLOGY OF THE YORKSHIRE OOLITES.

By WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S.

(Continued from Decade III. Vol. II. p. 159.)

(PLATE V.)

Order OPISTHOBRANCHIATA, Milne-Edwards.

THE species belonging to this Order, which are enumerated below and figured in the accompanying Plate, occur in the Lower Oolites without exception. The Oxfordian beds in Yorkshire have not been productive in fossils of this kind: the only known species—*Actæon retusus*, Phil.—has already been described in the "Corallian Gasteropoda" (GEOL. MAG. 1881, p. 127, Pl. IV. Fig. 7). The Tornatellidæ are the best represented, and especially *Actæonina*, but none are numerous, and really good specimens, suitable for accurate description, are rare indeed.

Genus ACTÆONINA, D'Orbigny, 1850 = *Orthostoma*, Deshayes.

There has been some hesitation on the part of authors in accepting D'Orbigny's name for this very important genus: accordingly we find that *Orthostoma* was adopted by Buvignier and also by De Loriol in his earlier works. But the latter author in 1874 finally accepted D'Orbigny's generic name. Into the question of priority it is hardly necessary to enter here: it is sufficient to mention that *Orthostoma* is inapplicable, as having been used for another genus at an earlier date.

The genus *Actæonina* is interesting to the palæontologist as perhaps the oldest member of the Tornatellidæ, dating from the Carboniferous period. It is best represented in the Jurassic period, but failed considerably during the Cretaceous. Stoliczka suggests that *Auriculina*, Gray, dredged in 63 fathoms, may be the modern representative of *Actæonina*. According to D'Orbigny, the maximum development of the genus was attained during the deposition of the Lower Lias. Tate and Blake enumerate six species of *Actæonina* from the Yorkshire Lias, but one of them must be referred to another genus. *Actæonina* is singularly scarce in the Inferior Oolite of Dorset-Somerset, and not a single species was quoted by Mr. Tawney in the "Dundry Gasteropoda." The genus is better represented in the Inferior Oolite of the Cotteswolds, and also in the Lincolnshire Limestone.

As originally constituted, this genus was made to comprehend the so-called "Cones" of the Lias. The specimens described below are all more or less turrited and would come within the following definition. "Shell turrited, or ovate, moderately thick, with more or less elevated spire, inner lip flatly thickened at the edge, not plicated or turrited, aperture evenly rounded in front; the last whorl being always anteriorly, somewhat suddenly contracted. The surface of many *Actæoninæ* appears to be perfectly smooth, but it is more likely this is only in consequence of the uppermost punctated layer of the shell having been removed."[1]

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[1] Stoliczka, Cretaceous Gasteropoda of Southern India, p. 399.

85.—ACTÆONINA HUMERALIS, Phillips, 1829. Plate V. Figs. 1, 1*a*,

1829 and 1835.	*Actæon humeralis*, Phillips, G.Y. p. 129, pl. xi. fig. 34.
1849.	*Actæonina humeralis*, D'Orb. (Phil.), Prod. i. p. 264, Et. Baj.
1854.	*Actæon humeralis*, Phil., Morr. Cat. p. 233.
1875.	*Actæon humeralis*, Phillips, G.Y. 3rd ed. p. 260, pl. xi. fig. 34.

Compare also

1852.	*Actæonina Sarthacensis*, D'Orb. Terr. Jurass. vol. ii. p. 167, p 286, figs. 1 and 2.
1876.	*Actæonina chrysalis*, Tate and Blake, Yorkshire Lias, p. 356, p x. fig. 23.

Bibliography, etc.—Phillips's type belonged to Bean, and i amongst those preserved in the York Museum.

Descriptions.—Specimen from the Dogger (zone 1), Peak (Blu Wyke). York Museum. Figs. 1, 1*a*. ? THE TYPE.

Height	15½ millimètres.
Width in proportion to height	48 : 100.
Spiral angle	66°.
Length of body-whorl to total height	71 : 100.

N.B.—The specimen is a trifle compressed, and half-skinne Shell ovate-oblong and composed of about 6 whorls. The spi occupies three-tenths of the entire height, and increases with tole able regularity; suture rather oblique. The whorls of the spire ar flat atop, and marked on the shoulder by a grooved line, whic produces two steps, or a double tabulation; sides of the whorls sul compressed. The groove on the shoulder is very distinct in th body-whorl, which is large and cylindrical, and in its present con dition smooth, or at most marked with indistinct lines of growtl Faint indications of spiral ornament may be noted in the base.

The length of the aperture is about two-thirds the height of th shell. It is narrow behind, wide in front: outer lip straight (*O thostoma*), columella smooth and slightly encrusted, but withou plications; termination of the aperture evenly rounded.[1]

Another specimen.—From the same horizon, locality, and colle tion. Fig. 3.

Approximate	Height	12 millimètres.
	Width in proportion to height	43 : 100.
	Spiral angle	62°.

Seven whorls may be counted, and probably the specimen co tained eight. The spire is very sharp and well preserved, and th double tabulation produced by the grooved line on the shoulder the whorls conspicuous. A fine system of striato-punctate lines i visible on the body-whorl, and these are rather stronger towards th base, especially in the region of the columella.

Another specimen.—Same horizon and locality. Leckenby Co lection. Not figured.

This one is 28 mm. in height, being nearly twice the size of th specimen first described (Fig. 1), which is an unusually fine on There are no indications whatever of spiral ornament: indeed th smaller shells usually show the fine spiral lines better than th larger ones. The shortest specimen in the Leckenby Collection measures about 7 mm.

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[1] It might seem superfluous to enumerate some of these points, which a characters of the genus; but since this species is still quoted as an *Actæon* in t last edition of the Geology of Yorkshire, a full description is the more necessary.

Relations and Distribution.—This is probably the most abundant representative of the Tornatellidæ in the Yorkshire Dogger, though far from being common. As we have seen, it varies greatly in size. The question of spiral striation is in a great measure a question of conditions of preservation. The larger the specimen the less likely it is to exhibit this feature. A very fine and close system of spiral striation may therefore be regarded as one of the characters of *Act. humeralis*, serving together with other peculiarities to connect it with *Act. Sarthacensis*, which is probably a representative, rather than an identical species, possessed of a smaller habit of growth.

I am inclined to think that *Act. chrysalis* is even more closely related. Tate and Blake's species is described as follows: "Shell oblong-ovate, whorls 5, subconvex, depressed at the suture, with a single impressed line on the shoulder of the whorl, marked with transverse plications and fine striæ." The single impressed line at the shoulder produces, it is believed, the kind of double tabulation so characteristic of *Act. humeralis*.

Two examples of *Act. chrysalis* are recorded by Tate and Blake from the *Spinatus*-zone of Eston and Upleatham.

86.—Actæonina, sp. Plate V. Fig. 2.

Description.—Specimen from the Dogger (zone 1), Peak (Blue Wyke). Bean Collection, British Museum.

Approximate	Height	12 millimètres.
	Spiral angle	78°.

Shell oval and composed of about 6 whorls. Spire regular, apex moderately acute. Whorls smooth, tumid, and sloping in the direction of the mean spiral angle, with no trace of tabulation on the whorls of the spire: suture conspicuous. Body-whorl large, ovate, and marked by broad lines of growth, which are nearly straight. Other indications wanting.

This form is distinguished from *Act. humeralis* by its wider spiral angle, by the tumid and non-tabulate character of the whorls, and by its freedom, even in a well-preserved specimen, of any trace of spiral ornamentation, and by the broad lines of growth.

The specimen is the only one of the kind from the Dogger ever seen by me. As a temporary name, it might be distinguished under the title of *Actæonina tumescens*.

87.—Actæonina gigantea, Deslongchamps, 1842 (obtuse variety). Not figured.

1842. *Tornatella gigantea*, Deslongchamps, Mém. Soc. Linn. Norm. vii. p. 137, pl. 10, figs. 27 and 28.
1850. *Actæonina gigantea*, Desl. Morris and Lycett, Gt. Ool. Moll. p. 119, pl. xv. fig. 13.
1852. *Actæonina Deslongchampsii*, D'Orbigny. Terr. Jur. ii. p. 171, pl. 286, fig. 11.
1875. *Actæonina gigantea*, Desl. Phillips G. Y. 3rd ed. p. 260.

The specimen, originally described and figured by Deslongchamps, was from the Great Oolite of Ranville, where D'Orbigny says it is always found as a cast. He objected to Deslongchamps' name on the ground that it had already been given by Sowerby to another species. This objection is not regarded as valid.

Phillips, in his last edition, says that *Act. gigantea* occurs in the G. O. (? Grey Oolite) of the White Nab: *i.e.* on the horizon of the Scarborough Limestone. The only specimen ever seen by me is the one in the Bean Collection at the British Museum; this is a cast, and probably comes from the Millepore Rock of Sycarham just round the north point of Cloughton Wyke. I believe it to be the same specimen as the one figured by Morris and Lycett. It has a wider spiral angle than D'Orbigny allows, and may be regarded as an obtuse variety, approaching certain forms of *Act. Scarburgensis.* Indeed, except in being longer, the Millepore specimen referred to *Act. gigantea* is scarcely to be distinguished from the variety of *Act. Scarburgensis* figured herewith (Fig. 9). In the Millepore specimen the aperture is proportionally shorter. It was evidently a shell with a very thin test, hence its occurrence for the most part as a cast.

Stated to occur in the upper beds of the I.O. at Minchinhampton.

88.—ACTÆONINA SCARBURGENSIS, Lycett, 1863. Plate V. Figs. 9, 9*a*.

1863. *Actæonina Scarburgensis*, Lyc. Supp. Gt. Ool. Moll. p. 28, pl. xxxiii. fig. 13.
1875. *Actæonina Scarburgensis*, Lyc. Phillips, G.Y. 3rd ed. p. 260.

Bibliography, etc.—The author describes his species as ventricose, being shorter and more tumid than *Act. convoluta*, Lyc. Length 14 lines; diameter of last volution 10 lines. The test, which is thin, is partially preserved: it has a corneous aspect. From a single specimen in the Leckenby Collection.

Descriptions, A.—ELONGATE VARIETY. Specimen from the Cornbrash (zone 4), Scarborough. My collection. Almost in the condition of a cast. Figs. 9, 9*a*.

Height	35 millimètres.
Proportion of width to entire height	51 : 100.
Spiral angle	70°.
Height of body-whorl to entire shell	70 : 100.

Shell oval, smooth, and composed of 6 or 7 whorls, with a spire about three-tenths the entire height; suture slightly sunk. The whorls are rounded at the shoulder, sub-compressed at the sides. Body-whorl large and moderately ventricose, but with flat sides. The aperture is thoroughly characteristic of *Actæonina.* There is probably some indication of a slight umbilical slit.

A portion of the shell towards the base is preserved, being rather less than ½ mm. in thickness, and portions of the inner layer of the shell of extreme tenuity adhere to the cast and retain the impression of the lines of growth.

Another specimen, B.—VENTRICOSE VARIETY. Same horizon and locality. Leckenby Collection. Not figured.

This resembles Lycett's type (which is also in the same collection), but it has a more perfect spire, though less shell on the body-whorl. The spiral angle is nearly 80°. In the spire alone 7 whorls are preserved, and exhibit the channelling of the suture very distinctly. The body-whorl is relatively shorter and stouter than in the specimen figured (Fig. 9). But the smooth and flowing outline there shown is even more conspicuous.

Relations and Distribution.—I must confess to a strong suspicion that *Act. Scarburgensis* is closely related to *Act. gigantea,* of which it may be regarded as a ventricose variety more or less pronounced. There appears to me to be no specific or even varietal distinction between the Millepore specimen and variety *A* of the Scarborough fossils. Hence whatever name we give them, they must be regarded as the same species. This serves to show how difficult it is to construct a Table of Fossils which shall faithfully represent all the facts of the case. On the whole, setting names altogether on one side, this would seem to be a "demoid" group, which, except in the matter of size and of relative stoutness, may be regarded as represented in many districts and in more than one horizon.

89.—ACTÆONINA TUMIDULA, Morris and Lycett, 1850. Pl. V. Fig. 7.

1850. *Actæonina tumidula,* Morris and Lycett, Gt. Ool. Moll. p. 120, pl. xv. fig. 14.

Compare—

Actæonina Davoustana, D'Orbigny, Terr. Jurass. ii. p. 169, pl. 286, fig. 5–6. Et. Baj.

Description.—Specimen from the Scarborough Limestone (zone 3), White Nab. Bean Collection, British Museum. TYPE REFIGURED.

Spiral angle .... ? 100°.

The specimen is, it seems to me, in the condition of a cast peculiar to the Grey Oolite of this locality. The following is the author's description—"Shell small, spire depressed, volutions very narrow, rounded, their sutures deeply depressed: the last whorl gibbous, aperture an elongated oval. This species is shorter than any other with which we are acquainted. . . . . Length 4½ lines, transverse diameter 3½ lines."

Relations and Distribution. —This species was founded on an unique specimen, almost, if not altogether, in the condition of a cast. However, when the test is extremely thin, as in this case, the cast gives the general outline with considerable fidelity. The tumid and ventricose character of the body-whorl seems to connect it with var. *B* of *Act. Scarburgensis,* but the spire is altogether more stumpy, and the spiral angle consequently wider; if, indeed, these indications can be relied upon in a fossil presenting such conditions of preservation.

I have not seen another specimen in any of the collections. D'Orbigny's species, to which reference is made, is even more ventricose, having a spiral angle of 115°.

90.—? ACTÆONINA GLABRA, Phillips, 1829. Plate V. Figs. 6, 6*a*.

1829, 1835. *Actæon glaber* (Bean MS.), Phillips, G.Y. p. 124, pl. ix. fig. 3.
1849. *Actæonina glabra,* D'Orb. (Phil.), Prod. i. p. 264, Et. Baj.
1850. *Actæonina glabra,* Phil., Morr. and Lycett, Gt. Ool. Moll. p. 120, pl. xv. fig. 10.
1875. *Actæonina glabra,* Phillips, G.Y. 3rd edition, p. 260, pl. ix. fig. 31.

Bibliography, etc.—The type of *Actæon glaber,* Bean, has never been seen by me, but the shell now figured belongs to the Bean Collection and is so described. I have sometimes fancied that these shells should be grouped under *Cylindrites*, but have never been able to satisfy myself of the plication of the columella, though the anterior portion of the aperture has a general resemblance to Morris and Lycett's genus. Specimens, even the best, are in such a condition that a perfectly accurate diagnosis is almost impossible.

Description. — Specimen from the Millepore Rock (zone 2), Cloughton. Bean Collection. British Museum.

Approximate	Height	16 millimètres.
	Proportion of width to height	42 : 100.
	Spiral angle	80°.
	Body-whorl to total height	90 : 100.

Shell cylindro-conical, with a very short spire. The whorls of the spire, about 3 in number, are subtumid, with a slope in the direction of the spiral angle, suture distinct. The body-whorl is very long, and large relatively to the spire: the shoulder is broad and nearly square close to the suture, then droops towards the long compressed sides; it is very slightly tapered off anteriorly. Shell very smooth in its present condition.

The aperture is extremely long and very narrow in the upper half, but expands anteriorly owing to the hollowing out of the columellar region. The columellar lip is thickened and drawn out obliquely. No actual plication can be seen, owing to the imperfection of this portion of the specimen.

Relations and Distribution.—There is too much uncertainty about these ill-preserved specimens for any serious attempt at correlation. This species has been found sparingly in the Millepore Rock, and probably in the Scarborough Limestone, and I have seen one specimen from the Dogger. The specimen figured is above an average size.

91.—ACTÆONINA CINEREA, sp.n. Pl. V. Figs. 8, 8*a*.

Description.—Specimen from the Scarborough Limestone (zone 3), Cloughton. Leckenby Collection.

Height	26½ millimètres.
Proportion of width to total height	51 : 100.
Spiral angle	90°.
Body-whorl to total height.................	80 : 100.

Shell cylindro-conical, with a regular spire about one-fifth the total height. The angle of increase of the spire is exactly a right angle. Whorls of the spire probably 5, short, subtumid, and devoid of ornament; suture distinct. Shoulder of the body-whorl extremely broad and square. Body-whorl relatively large and cylindrical; sides compressed, and almost constricted just below the shoulder, but presenting on the whole a nearly straight outline.

Shell substance moderately thin, without ornament, but marked by rugose and slightly curved lines of growth, which also leave their impression on the internal cast, a portion of which is visible in the specimen. The aperture is partly involved in matrix, but is evidently long, and extremely narrow in the posterior two-thirds, the outer lip being very straight; anterior portion of the aperture somewhat restricted, with a short columella, which exhibits no signs of plication (unless these have been effaced in developing the specimen): termination of the aperture apparently round and even, but this portion has been cut out of the matrix.

Relations and Distribution.—Induced probably by the character of the aperture in Phillips' figure, Mr. Leckenby referred this species to "*Actæon glaber*," erroneously as I cannot help thinking. No doubt the cylindro-conical outline of the shell, the tabulation of the body-whorl, and the flatness of its sides, are strong points of resemblance; but the proportions are different, to say nothing of other features, which a bad state of preservation, especially with regard to the termination of the aperture, renders somewhat difficult to describe.

Three specimens are known to me from the Scarborough Limestone, and there is a very stout variety, apparently belonging to this species, in Mr. Leckenby's Cornbrash collection. The rectangular outline of the whorls and stumpy spire serve to separate it from *Act. Scarburgensis.*

EXPLANATION OF PLATE V.

Figs. 1, 1*a*.	*Actæonina humeralis*, Phillips. Dogger, Peak. York Museum (shell partially preserved). Back and front. × 2.
„ 2.	*Actæonina* sp. Dogger, Peak. Bean Collection, British Museum. Back. × 2.
„ 3.	*Actæonina humeralis*, Phil. Dogger, Peak. York Museum (specimen showing the striæ). Back. × 2.
„ 4.	*Actæon Sedgvici*, Phillips. Dogger, Peak. Bean Collection, British Museum. Back. × 2.
„ 5.	*Actæon pullus*, Morris and Lycett (var. of *Ac. Sedgvici*). Millepore Rock of the coast. Bean Collection, British Museum. Front. × 2.
„ 6 and 6*a*.	*Actæonina glabra*, Phillips. Millepore Rock of the coast. Bean Collection, British Museum. Back and front. × 2.
„ 7.	*Actæonina tumidula*, Morris and Lycett. Scarborough Limestone, White Nab. Bean Collection, British Museum. Type refigured. Front. × 2.
„ 8, 8*a*.	*Actæonina cinerea*, sp. n. Scarborough Limestone, Cloughton Wyke. Leckenby Collection. Back and front. Nat. size.
„ 9, 9*a*.	*Actæonina Scarburgensis.* Lycett (var. approaching *Act. gigantea*, Desl.). Cornbrash, Scarborough. My Collection. Back and front. Nat. size.
„ 10, 10*a*.	*Bulla undulata*, Bean. Cornbrash, Scarborough. Leckenby Collection. Back and front. Nat. size.
„ 11, 11*a*.	"*Trochus*" *jugosus*, Bean MS. Dogger, Peak. Bean Collection, British Museum. Nat. size, and portion enlarged.

(*To be concluded in our next Number.*)

III.—On the Presence of Syenite and Gabbro in Essex County, Massachusetts.

By Dr. M. E. Wadsworth.

Syenite.—Much of the eastern coast of Essex County, Massachusetts, extending from Salem to a point beyond West Manchester, has been found by the writer to be occupied by a typical syenite of a reddish and greyish colour, which in its macroscopic characters appears to be identical with that from Planen'schen Grund, Saxony. The syenite in places contains much biotite, and also, near West Manchester, quartz grains (segregations?). This syenite is often cut by dykes of a fine-grained greyish syenite, which holds the same relation to the syenite proper as the micro-granite dykes do to the granite of the region, and hence, for convenience of description, the rock of the syenite dykes may be styled micro-syenite.

The relation of the syenite proper to the common hornblendic and lepidomelane granite[1] of the region (the syenite of Hitchcock, and other American authors) has not yet been made out distinctly. Both are eruptive, and heretofore have been taken to form the same rock-mass. In fact, the syenite is partly in the areas mapped as belonging to the Norian or "Naugue Head" formation, and partly in that mapped as belonging to the Huronian. Near West Manchester the granite rises obliquely in a dome-shaped mass from beneath the syenite, but the actual contact was not seen; and elsewhere, when the two rocks were in juxtaposition, good contacts were not found. The difficulty in determining their relations was further increased by their close resemblance to each other macroscopically, and the fact that the micro-granite and micro-syenite dykes, by which the granite and syenite are respectively cut, are closely alike. So far as seen, the granite occupies the coast northward from near "Manchester-by-the-Sea," and the interior of the country going southward from that point. At least, an examination of all the railway cuttings between Manchester and Salem revealed syenite at only two of them, and those were near the sea-shore. The syenite, however, occupies a large portion of the coast-line between Manchester and Salem. The preponderance of evidence is that the granite is the younger rock, unless it is contemporaneous with the syenite.

Gabbro.—On Woodbury's Point, Beverley, occurs a gneissoid schist which is probably the oldest rock in the vicinity. This is cut by irregular dykes of gabbro which generally run approximately parallel to the foliation of the schist. This gabbro varies much in structure in different portions even in the same dyke, three different types being found with various intermediate grades. 1. A compact, tough, milk-white or waxy felspathic mass, containing a few grains of diallage, and closely resembling many specimens of the Volpersdorf gabbro. 2. A crystalline rock composed of approximately equal amounts of felspar and diallage, and in structure is like a coarsely crystalline diabase, or the common crystalline gabbros like those from Raduthal and Neurode. 3. A rock in which the felspar becomes subordinate, serving merely as a matrix to hold the large porphyritic crystals of diallage, some of which are two or three inches long. From the alterations observed by the writer in the gabbros from this place, San Domingo, and other localities, he has been led to believe that many of the coarsely crystalline diorites of these regions have been formed from the alteration of gabbro, in which the diallage has been replaced by secondary hornblende. The before-mentioned syenite was found cutting the gabbro and holding fragments of it, while the micro-syenite contains diallage fragments at the places in which it traverses the gabbro.

In the granite of Davis Neck, Bay View, Gloucester, a variety of gabbro occurs quite abundantly. This is a grey, coarsely crystalline rock, with predominating felspar. The felspar is in approximately square prisms, weathering grey, but often on the fresh fracture having a bluish or pinkish tinge. In many parts this gabbro contains crystals and masses of a pinkish striated felspar (probably labradorite), one piece of which was fifteen inches long by seven inches broad. The gabbro occurs in rounded crater or neck-like masses, and in dykes, one of which is twenty-seven feet in width. The largest gabbro area holds in its centre a pinkish mass composed mainly of the pinkish felspar before mentioned. This mass is nearly round in outline, and from fourteen to fifteen feet in diameter, while it apparently widens in depth. This eruptive gabbro is like much of that which has been regarded as typical of the so-called Norian formation, and apparently to a boulder of it found on Marblehead Neck is due the first suggestion of the presence of the Norian formation in Eastern Massachusetts. Boulders both of the Davis Neck and Woodbury Point gabbros have been observed by the writer freely scattered in the drift over Middlesex and Essex Counties, and therefore these rocks doubtless exist *in situ* in many other localities than the two mentioned.

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[1] Proc. Boston Soc. Nat. Hist. 1878, vol. xix. pp. 309-316.

Elæolite (*Zircon*) *Syenite.*—The writer has previously pointed out[1] the existence in Marblehead of a zircon syenite like that from Fredericksvæm, Norway. The same rock further occurs in Salem, particularly on Salem Neck, where it forms dykes and large masses in the diabase. It was here that sodalite and elæolite were found in an apparent boulder many years ago, and the writer has discovered that the coarser crystalline portions of the zircon syenite contain elæolite in quite large and abundant masses, giving rise to the rock known as elæolite syenite. The zircon syenite is further found on the Beverley shore.

Dykes.—The entire coast-line is more or less cut by dykes of micro-granite, micro-syenite, quartz-porphyry, diabase, diorite, and melaphyre. Part of the diabase and melaphyre dykes are non-porphyritic on the sides, but in the intermediate portions they are filled with felspar crystals, varying from minute ones to giant forms six to eight inches in length. Many of these crystals are of irregular outline, and have been penetrated by the ground-mass.

Trachyte.—A dyke of trachyte of the same kind as that previously described by the writer[2] as forming an overflow on Marblehead Neck, was found on the Beverley shore, near the Manchester boundary-line. This dyke cuts the granite, both walls being found, and at the point observed it was forty-four inches wide.

Geological Succession.—If the sequence of all the dykes cutting one another be taken, numerous epochs of eruption can be found, but speaking broadly the general order of arrangement would, from the present evidence, appear to be as follows:—

1. The schistose rocks which seem to form the basis, and to be of sedimentary origin. 2. The older basaltic rocks—gabbro, diabase, and diorite—which have been intruded through the schist and occupy large areas of the country. 3. Syenite. 4. Elæolite (zircon) syenite.

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[1] Proc. Boston Soc. Nat. Hist. Feb. 1, 1882.

[2] Proc. Boston Soc. Nat. Hist. 1881, vol. xxi. pp. 288-294.

5. Granite. 6. Felsite. 7. The later basaltic rocks—diabase and melaphyre. 8. Trachyte.

The above is given as the results of field observations in the summer of 1883, the specimens not having been unpacked since collected. It is intended to make a microscopic examination of the rocks at the earliest time my duties will permit, and to publish the results with further details of the field relations.

IV.—ON A POSSIBLE CAUSE OF THE DISTURBANCE OF MAGNETIC COMPASS-NEEDLES DURING EARTHQUAKES.

By CHARLES DAVISON, B.A.,
Mathematical Master at King Edward's School, Birmingham.

FROM time to time, during earthquake-shocks, magnetic compass-needles within the disturbed areas have been seen suddenly deflected from their position of rest, returning to it shortly, after one or more oscillations. This movement admits of two very different interpretations. Either it may be attributed to an intimate connexion between earthquakes and terrestrial magnetism, or it may be regarded as merely a consequence of the *shock* of the earthquake. The object of this note is to point out a possible mechanical cause, and to guard, therefore, against a too hasty assumption of a magnetic origin for these disturbances.

The following examples may be given to illustrate the nature of these movements:

(1.) On August 28, 1787, an earthquake was felt at Stuttgart, Munich, Augsburg, Landshut. Innspruck, Pappenheim, Ansbach, Empten, Dillingen, Ratisbon, Zurich, and Bâle. At Innspruck, the direction of the shock was from S.W. to N.E. A magnetic needle at the same place deviated 0° 12′ to the east.[1] Here, then, the south end of the needle moved in the direction opposite to that of the earthquake-shock.

(2.) On December 2, 1841, an earthquake was felt at the following places:—At St. Rambert-en-Bugey at 7·47 P.M.; Lyons at 7·50; Geneva and Chambéry at 7·53; Chessy, Anse, and in the neighbourhood of Berne at 8; and at Lons-le-Saulnier at 8·15, and again at 8·30. At Billey the direction of the shock was said to be from N. to S.; at Geneva from S.W. to N.E.; and at St. Rambert-en-Bugey, apparently from E. to W. From the recorded times and directions, it follows that the focus of the earthquake must have lain to the east of the meridian of Lyons. At this town a compass-needle suddenly turned from N. to N.N.W.[2] Here again, then, the south end of the needle moved in the opposite direction to that of the shock.

(3.) On February 20, 1835, occurred the great earthquake of Concepcion, described by Fitzroy, Caldcleugh, Darwin, and others. There is some uncertainty as to the direction of the shock, but the balance of the evidence is in favour of the seismic focus having been to the west of the South American continent. In his classical memoir, "On the Connexion of certain Volcanic Phenomena in South America, etc.,"[1] Mr. Darwin quotes the observation of Mr. Douglas, made at the moment of the shock in the island of Chiloe, as follows: "Pocket compass placed level on the ground, N. point set to lubbers' point; remarked that it vibrated during the violent shocks two points to westward and only half a point to eastward; stood at N. when the motion was less violent. Four minutes afterwards, a shock more violent than any of the preceding ones, affecting the compass as before; another violent shock, and then the movements became gradually less distinct, and eight minutes after the first commencement, they entirely ceased." In this case, though one not quite free from doubt, the north end of the compass-needle seems to have moved in the direction opposite to that of the earthquake-shock.

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[1] R. Mallet, Catalogue of recorded Earthquakes, Brit. Assoc. Rep. 1854, p. 18.
[2] *Ibid.* p. 314.

Explanation of the Movement.—In the memoir above mentioned, Mr. Darwin continues: "I have quoted Mr. Douglas's statement with regard to the compass, although it is not clear how any movement could have forced it to oscillate towards one side more than to another. I presume, however, if the needle with its card had not been acted on by the magnetic force, it would have been thrown in the trough (if such an expression may be used) of the undulation, that is, in a N.W. and S.E. line, and, therefore, that the *recurrence* of this tendency acting against the polar attraction, caused the unequal oscillations described."

Mr. Mallet has shown that the impulse communicated to a body by the shock of an earthquake is, *cæteris paribus*, proportional to the mass of the body, and acts in the direction opposite to that of the earthquake-motion at the instant considered. If, therefore, the masses of the two halves of the magnetic needle were equal, the impulse communicated to both would be the same, and no motion would ensue. But, to counteract the dipping tendency of the magnetic needle, the end that would naturally be higher is weighted so that the needle may swing horizontally. Hence, the masses of the two halves being unequal, the needle will receive a differential impulse proportional to the added weight, and the heavier end will swing round in the direction opposite to that of the earthquake motion. The resultants of the magnetic force and of the subsequent impulses communicated during the earthquake will tend to bring the needle back to its position of rest, or cause it to describe further oscillations of greater or less magnitude.

Now, in Europe, the dip-needle inclines towards the north, and the south end of the compass-needle must therefore be weighted. In Chili, the needle dips towards the south, and the north end must be weighted. In the first two of the above cases, then, and probably in the third also,[2] *the first movement of the heavier end was in the direction opposite to that of the earthquake motion.*

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[1] Trans. Geol. Soc., second series, vol. v. pt. iii. pp. 602–3.

[2] These are the only instances I have been able to find in which the direction of the movement of the compass-needle is stated. Others only mentioning a movement at the instant of the shock are of course much more commonly recorded.

REVIEWS.

I.—The Dinocerata, a Monograph of an Extinct Order of Gigantic Mammals. By Othniel Charles Marsh, M.A., F.G.S., of Yale College, New Haven, Conn., U.S.A. 4to. pp. i–xviii, and 237; with 56 Plates and 200 Woodcuts. Being Vol. X. of the United States Geological Survey of the Territories. Advance copy issued with the permission of the Director. (Washington: 1884.)

IN the Geological Magazine for 1880, Decade II. Vol. VII. pp. 522–526, we had the pleasure to draw attention to the appearance of the first volume of this magnificent series of United States Geological Survey Monographs by Professor Marsh, that on the *Odontornithes*, or Toothed-Birds, of the Cretaceous deposits of the Rocky Mountains in North America.

The present volume, which corresponds in style with it, and may be properly called Volume II. of the series, is equally worthy of the attention of palæontologists. It contains a most complete record of a peculiar order of Mammals which have been obtained by the author with vast labour and expense, and with no little personal risk, from the early Tertiary strata of the great central plateau of the Continent. But we will let Professor Marsh speak for himself.

"Among the many extinct animals discovered in the Tertiary deposits of the Rocky Mountain region, none, perhaps, are more remarkable than the huge mammals of the order *Dinocerata*. Their remains have hitherto been found in a single Eocene lake-basin in Wyoming, and none are known from any other part of this country, or from the Old World. These gigantic beasts, which nearly equalled the Elephant in size, roamed in great numbers about the borders of the ancient tropical lake in which many of them were entombed.

"This lake-basin, now drained by the Green River, the main tributary of the Colorado, slowly filled up with sediment, but remained a lake so long that the deposits formed in it, during Eocene time, reached a vertical thickness of more than a mile. The Wasatch Mountains on the West, and the Uinta chain on the South, were the main sources of this sediment, and still protect it; but the Wind River range to the North, and other mountain elevations, also sent down a vast amount of material into this great fresh-water lake, then more than one hundred miles in extent.

"At the present time, this ancient lake-basin, now six to eight thousand feet above the sea, shows evidence of a vast erosion, and probably more than one-half of the deposits once left in it have been washed away, mainly through the Colorado River. What remains, forms one of the most picturesque regions in the whole West, veritable *mauvaises terres*, or 'bad-lands,' where slow denudation has carved out cliffs, peaks, and columns of the most fantastic shapes and varied colours. This same action has brought to light the remains of many extinct animals, and the bones of the *Dinocerata*, from their great size, naturally first attract the attention of the explorer.

"The first remains of the *Dinocerata* discovered were found by the author, in September, 1870, while investigating this Eocene lake-basin, which had never before been explored. Various remains of this group were also collected by other members of the expedition, and among the specimens thus secured was the type of *Tinoceras anceps*, described by the author in the following year, and now more fully in the present volume. In the same geological horizon with these remains, a rich and varied vertebrate fauna, hitherto unknown, was found.

"Among the animals here represented were ancestral forms of the modern Horse and Tapir, and also of the Pig. Many others were found related to the recent Lemurs; also various Carnivores, Insectivores, Rodents, and small Marsupials; and of still more importance, remains were here brought to light of another new order of mammals, the Tillodonts, quite unlike any now living. Crocodiles, Tortoises, Lizards, Serpents, and Fishes also swarmed in and about the waters of this ancient lake, while around its borders grew Palms, and other tropical vegetation.

"The remarkable Eocene basin north of the Uinta Mountains, where alone the *Dinocerata* had been found, offered so inviting a field for exploration, that in the spring of the following year, 1871, the author began its systematic investigation. An expedition was again organized, with an escort of United States soldiers, and the work continued during the entire season."

In 1872, 73, 74, and 75, these researches were continued by Prof. Marsh with unabated energy; finally, during the entire season of 1882, the work was again vigorously prosecuted by the author; and after July of that year, by the United States Geological Survey.

The specimens brought together in Yale College Museum alone represent more than 200 individuals of the *Dinocerata*, besides a vast series of remains of other orders of animals. The author refers to the early labours of Dr. Leidy (who proposed the name of *Uintatherium* for certain specimens obtained by him); to Prof. Cope (who proposed the names *Loxolophodon*, *Eobasileus*, and *Bathyopsis* for various forms of *Dinocerata* which he had discovered). He also credits the staff of the Princeton College, whose collecting parties had secured numerous remains of *Dinocerata* and other fossils from the same localities. But the far larger collections obtained by Prof. Marsh for Yale College have left little to be desired in the way of additional evidence for the completion of his Monograph. The localities in which the *Dinocerata* have been found are on both sides of the Green River, and mainly south of the Union Pacific Railroad in Wyoming. About equal numbers of specimens were found east and west of the Green River, the distance between the extreme localities in this direction being more than one hundred miles. They occupy a well-marked geological horizon of the Middle Eocene.

"The *Dinocerata* form a well-marked order in the great group of *Ungulata*. In some of their characters, they resemble the *Artiodactyla*[1]

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[1] *Artiodactyla*, or *even-toed* Ungulata, or hoofed animals (Pig, Hippopotami, Camels, Deer, Antelopes, Sheep, Oxen, etc.).

(*Paraxonia*); in others they are like the *Perissodactyla*[1] (*Mesaxonia*); and in others still, they agree with the Proboscidians.[2] The points of similarity, however, are in most cases general characters, which point back to an earlier, primitive ungulate, rather than indicate a near affinity with existing forms of these groups.

"The *Dinocerata*, so far as now definitely known, may be placed in three genera, *Dinoceras*, Marsh, *Tinoceras*, Marsh, and *Uintatherium*, Leidy. The type specimen of *Uintatherium* was discovered near the base of the series of strata containing the remains of the *Dinocerata*. *Dinoceras*, so far as known, occurs only at a higher horizon, while *Tinoceras* has been found at the highest level of all. The characters of these three genera correspond in general with their geological position. *Uintatherium* appears to be the most primitive type, and *Tinoceras* the most specialized, *Dinoceras* being an intermediate form.

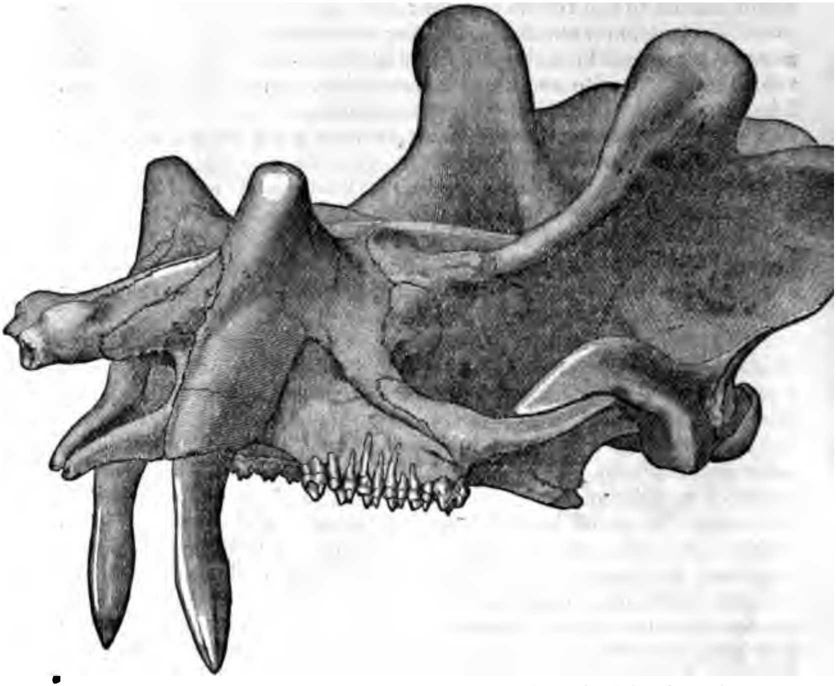

FIG. 1.—Skull of *Dinoceras mirabile*, Marsh (seen from the left side). One-sixth natural size. From the Eocene Tertiary Lacustrine deposits of Wyoming Territory, United States, North America.

"About thirty species of *Dinocerata*, more or less distinct, are recognized by the author in the Synopsis at the end of the volume.

"*The Skull.*—The skull of *Dinoceras mirabile* is long and narrow, the facial portion being greatly produced. The basal line, extending from the end of the premaxillaries along the palate to the lower margin of the foramen magnum, is nearly straight. The top of the skull supports three, separate, transverse pairs of osseous elevations, or horn-cores, which form its most conspicuous feature, and suggested the name of the genus. The smallest of these protuberances are situated near the extremity of the nasals; two others, much larger, arise from the maxillaries, in front of the orbits; while the largest are mainly on the parietals, and are supported by an enormous crest, which extends from near the orbits entirely around the lateral and posterior margins of the true cranium. These general characters are well shown in Figure 1, which represents the skull of the type specimen.

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[1] *Perissodactyla*, or *uneven-toed* (Horse, Tapir, Rhinoceros).

[2] *Proboscidia* (Elephant, *Mastodon*, *Dinotherium*).

"There are no upper incisors, but the canines in the male are enormously developed, forming sharp, trenchant, decurved tusks, which were each protected by a dependent process on the lower jaw. The premolar and molar teeth are very small.

"The orbit is large, and confluent with the temporal fossa. The latter is of great extent posteriorly, but the zygomatic arches are only moderately expanded. There is no post-orbital process.

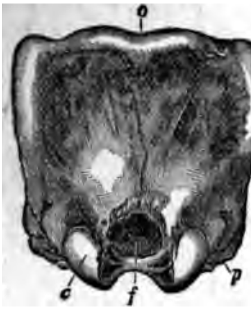

Fig. 2.—Posterior, or occipital surface of skull of *Dinoceras mirabile*, Marsh, one-eighth nat. size. *c*, occipital condyle; *f*, foramen magnum; *l*, lateral crest; *o*, occipital crest; *p*. post-tympanic process; *t*, crest behind temporal fossa.

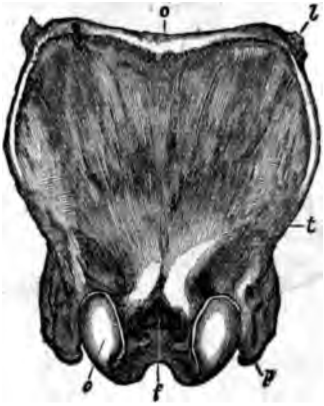

Fig. 3.—Posterior, or occipital surface of skull of *Tinoceras ingens*, Marsh, one-eighth natural size. (Letters the same as in Fig. 2.)

"The nasal bones are greatly elongated, being nearly half the length of the entire skull. They project forward over the anterior nares, and overhang the premaxillaries. They are thick and massive bones, especially in front, and are united together by a nearly straight suture.

"The anterior extremity of the nasal bones, in both *Dinoceras* and *Tinoceras*, is formed of an osseous projection, pointing forward and downward, and situated in front of and below the nasal protuberances. Several specimens in the Yale Museum show that this projection is formed of two separate ossifications, each in front of its respective nasal bone.

"These bones are a peculiar feature in the skull of *Dinocerata*, and may be called the pre-nasal bones. In very young animals, they are unossified; in adult animals they are distinct; but in very old animals they become coössified with the nasals, and with each other.

"The frontal bones in *Dinoceras mirabile* are shorter than the nasals (see Fig. 4). In all the known skulls of the *Dinocerata*, the median suture uniting the two frontals is entirely obliterated. The suture joining them with the nasals in front, and with the maxillaries on the side, is distinct in the type of *Dinoceras*.

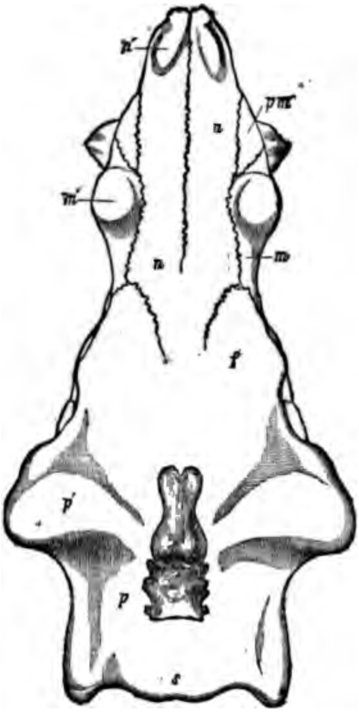

Fig. 4.—View of upper-surface of skull of *Dinoceras mirabile*, Marsh, with brain-cast in natural position. *f*, frontal bone; *m*, maxillary bone; *m'*, maxillary protuberance; *n*, nasal bone; *n'*, nasal protuberance; *p*, parietal bone; *p'*, parietal protuberance; *pm*, premaxillary bone; *s*, supra-occipital crest.

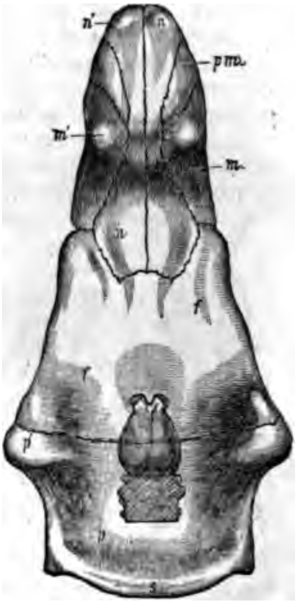

Fig. 5.—Skull of a young specimen of *Dinoceras distans*, Marsh, seen from above; with brain-cast in natural position. Both Figs. 4 and 5 are one-eighth natural size. The letters refer to the same parts of the skull in both figures.

"The maxillary bones form a large portion of the lateral surface of the skull. They contain all the teeth, except those of the lower jaw, and they also expand into the large median pair of osseous elevations, or horn-cores.

"In one young specimen, the fronto-parietal suture is still open and passes in a nearly straight line across the top of the cranium just in front of the summit of the cerebral hemispheres (see Fig. 5). It also divides the posterior elevations, or horn-cores, so as to leave the anterior part of them on the frontals, and the posterior and highest portion on the parietals.

"In all the crania of the *Dinocerata* examined, the parietal bones are firmly united to each other on the medial line, and with the supra-occipital behind.' . . . . . On the sides of the cranium, the parietals form the upper portion of the large temporal fossæ.

"The occipital region in all the known *Dinocerata* is large,

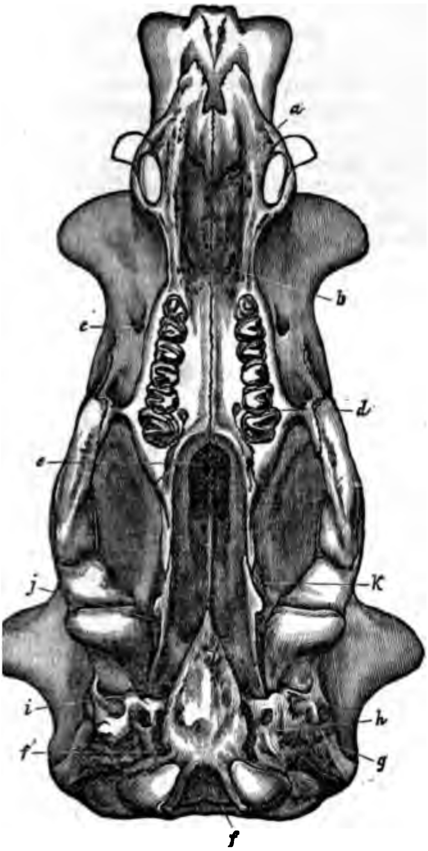

Fig. 6.—Palatal view of skull of *Tinoceras ingens*, Marsh; one-eighth natural size. *a*, anterior palatine foramen; *b*, palato-maxillary foramen; *c*, antorbital foramen; *d*, posterior palatine foramen; *e*, posterior nares; *f*, foramen magnum; *f'*, occipital foramen; *g*, stylomastoid foramen; *h*, foramen lacerum posterius; *i*, vascular foramen in basisphenoid; *j*, posterior opening of alisphenoid canal; *k*, anterior opening of alisphenoid canal; *l*, optic foramen.

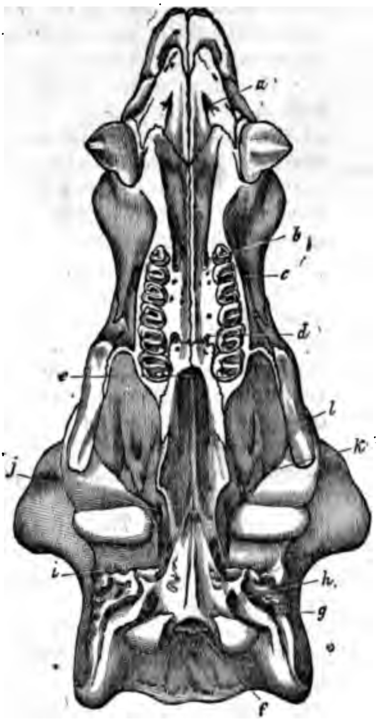

Fig. 7.—Palatal view of skull of *Dinoceras mirabile*, Marsh; one-eighth natural size. The explanation of the letters is the same as that for Fig. 6.

elevated and sub-quadrate in outline. It varies much in sha size in the different genera and species, and two of the pri forms are represented (see Figs. 2 and 3).

"The malar bone completes the anterior portion of the zyg arch, extending to the front of the orbit. The suture uniti malar with the maxillary remains distinct till adult life, an usually be traced, even in old animals. This forward exten the malar bone is a general ungulate character, and quite di from what is seen in the Proboscidians, where the malar for middle portion only of the zygomatic arch.

"The lachrymal is large, and forms the anterior border orbit (see Fig. 1). It is perforated by a large foramen. In *ceras mirabile*, this is oval in outline, with the apex above. base of the lachrymal is excavated for the posterior opening large antorbital foramen.

"The large canine tusk is entirely inclosed in the maxillary and in the genus *Dinoceras*, its root extends upward into th of the maxillary horn-core. In all known *Dinocerata*, ther diastema between the upper canine and the premolars.

"The premaxillary bones are edentulous, and, even in specimens, contain no teeth. The premaxillaries vary much i in the different genera and species.

"Two of the principal forms are shown in Figs. 6 and 7.

"The palate is very narrow and much excavated, especially in The bony palate extends back as far as the last upper molar, some specimens beyond. It is deeply excavated on each s the region of the diastema, and near the posterior part of ea cavation on either side is situated a large foramen, which i called the palato-maxillary foramen (Figs. 6 and 7, *b*).

"In the type of *Dinoceras*, the palatine fossa of the posterio is roofed over, so that the passage from the palate into the nasal cavities above leads forward and upward, as shown indis in Figure 7. In *Tinoceras ingens* and *Tinoceras pugnax*, the this fossa is excavated in front by a pair of oval aperture through these, the posterior nares open directly upward, as sented in Figure 6, *e*.

"*The Lower Jaw.*—The lower jaw in *Dinoceras* is as rema as the skull (see Figs. 8 and 9). Its most peculiar feature male is a massive decurved process on each ramus, extending ward and outward. These long, pendent processes were app to protect the upper canine tusks, which would otherwise b liable to be broken. . . . . In the female, this process is reduced in size, but is quite sufficient to protect the diminutiv which overlaps it.

"Another remarkable feature in the lower jaw of the *Din* is the posterior direction of the condyles, hitherto unkno Ungulates.

"In the genus *Dinoceras*, there are three incisor teeth, and incisiform canine on each side, forming a continuous series front extremity of the lower jaw. These are all of modera and inclined well forward, as in the ruminant mammals. Behind this series, and immediately over the dependent process, is a long

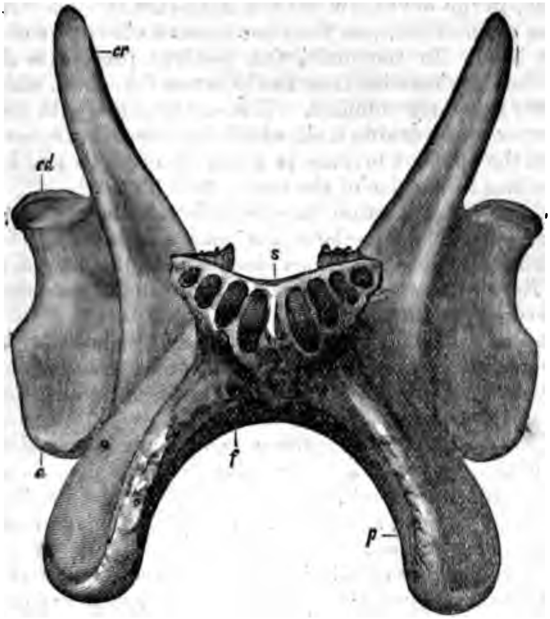

FIG. 8.—Front view of lower jaw of *Dinoceras laticeps*, Marsh : one-fourth nat. size. *a*, angle ; *cd*, condyle ; *cr*, coronoid process ; *s*, symphysis ; *f*, anterior foramen ; *p*. process for protection of the tusk.

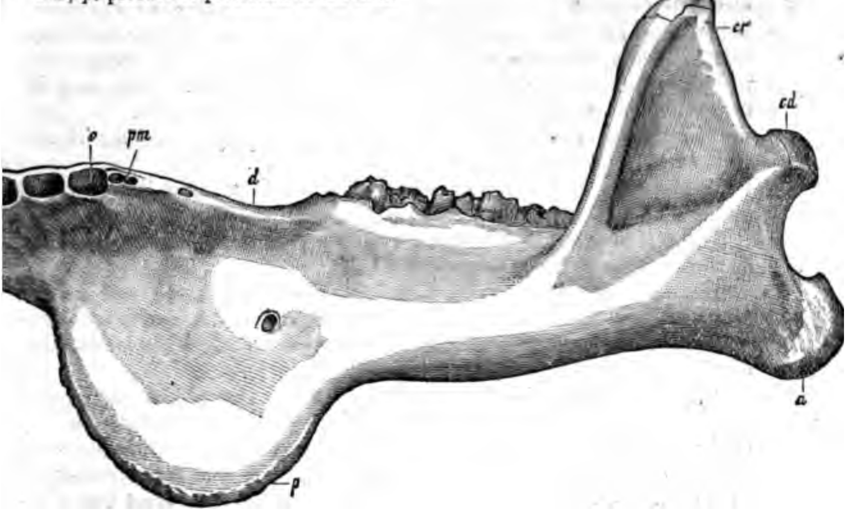

FIG. 9.—Left ramus of lower jaw of *Uintatherium segne*, Marsh; one-fourth nat. size. *c*, canine; *pm*, premolar; *d*, diastema. The explanation of the other letters is given under Fig. 8.

diastema. Further back, there are three premolars, and three molars, forming together a close series. This is the dentition, essentially, in the lower jaw of both *Dinoceras* and *Tinoceras*.

"In the genus *Tinoceras*, the same general characters of the lower jaws are seen. In the male, the pendent process is large and elongate, but less massive than in the genus *Dinoceras*, and its lower outline less regularly rounded. This corresponds with the position of the larger upper canine tusk, which it protects. In the female of *Tinoceras*, the pendent process is much reduced, its size in all cases corresponding to the size of the canine tusk above.

"That the same relation in size between the tusk and process below it holds equally in both the genera *Dinoceras* and *Tinoceras* is conclusively shown by various specimens in the Yale Museum.

"*The Teeth.*—The teeth of the *Dinocerata* constitute one of their most interesting features.

"In the genus *Dinoceras*, the dentition is represented by the following formula:—Incisors $\frac{0}{3}$, canines $\frac{1}{1}$, premolars $\frac{3}{3}$, molars $\frac{3}{3} = 34$.

"So far as now known, the same formula applies equally well to the genus *Tinoceras*.

"In *Uintatherium*, the dentition is apparently as follows:—Incisors $\frac{0}{3}$, canines $\frac{1}{1}$, premolars $\frac{3}{4}$, molars $\frac{3}{3} = 36$.

"In none of the *Dinocerata* have any upper incisors been found, even in the youngest specimens. The premaxillary bones appear to be entirely edentulous.

"In the lower jaw of all the known *Dinocerata*, there are three well-developed incisors on each side. They are inserted, each by a single root, and are procumbent, all directed well forward.

"The superior canines of *Dinoceras* are long, decurved, trenchant tusks. The crown is covered with enamel, and the root extends upward into the base of the maxillary protuberance, or horn-core. When the animal is young, these tusks grow from a persistent pulp, but in old age the cavity becomes nearly closed. In the male, these tusks are large and powerful, and extend downward nearly or quite to the extremity of the pendent process of the lower jaw.

"In the female of *Dinoceras*, the upper canines are small and slender, and protrude but little below the jaw."

The crowns of the upper premolar and molar teeth in *Dinoceras*, and, in fact, in all of the known *Dinocerata*, are remarkably short, with the roots well developed, forming a true brachyodont dentition, as in all early Tertiary ungulates.

"In each ramus of the lower jaw of *Dinoceras*, there is a close series of six teeth, three of which are premolars, and three true molars. These are all inserted each by two roots. This is also true of the genus *Tinoceras*.

"The molar teeth in *Dinocerata* appear to resemble more closely the corresponding teeth in the genus *Coryphodon* than those of any other animal. The general dentition, however, is quite distinct. *Coryphodon* has well-developed upper incisors, and a medium-sized upper canine, thus differing widely in these features from the *Dinocerata*."

The Brain.—"The brain of the *Dinocerata* is one of the most peculiar features of the group. It is especially remarkable for its diminutive size. It was proportionately smaller than in any other known mammal, recent or fossil, and even less than in some reptiles. It was, indeed, the most reptilian brain in any known mammal. In *Dinoceras mirabile*, the entire brain was actually so diminutive that it could apparently have been drawn through the neural canal of all the præsacral vertebræ, certainly through the cervicals and the lumbar ones.

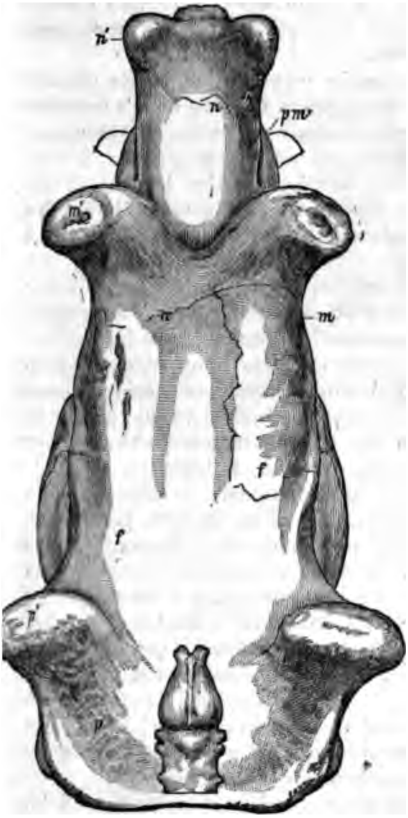

Fig. 10.—View of the upper surface of skull of *Tinoceras ingens*, Marsh; one-eighth nat. size, with brain-cast in position. *f*, frontal bone; *m*, maxillary bone; *m'*, maxillary protuberance; *n*, nasal bone; *n'*, nasal protuberance; *p*, parietal bone; *p'*, parietal protuberance; *pm*, premaxillary bone.

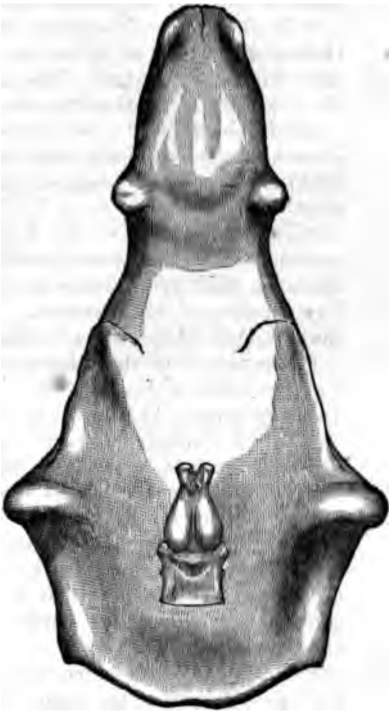

Fig. 11.—View of the upper surface of the skull of *Dinoceras laticeps*, Marsh, (female) with the brain-cast in position. One-eighth the natural size.

"The size of the entire brain, as compared with that of the cranium, is shown in the accompanying Figures, 4, 5, and 11. The size of the brain-cavity, and its position, in the skull in the genus *Tinoceras*, also, is represented in Figure 10.

"The most striking feature in the brain-cavity itself is the relatively small size of the cerebral fossa, this being but little larger than the cerebellar portion. The cerebral hemispheres did not extend at all over the cerebellum or the olfactory lobes. The latter were large, and continued forward.

"The nerves passing off from the brain were large, and can be made out with reasonable certainty. The olfactory lobes were separated in front by an osseous septum.

"In the genus *Tinoceras*, the brain was similar in its general characters to that of *Dinoceras*, but appears to have been somewhat more highly developed. The hemispheres were more elongate, and the olfactory lobes relatively smaller.

Brain-Growth.—"The *Dinocerata* are by far the largest of all known Eocene animals, and that they have, also, a very diminutive brain is a noteworthy fact, which attracted the author's attention soon after their discovery.

"The comparison of the brain in this group with that of other mammals from the same formation soon showed that the *Dinocerata*, although most remarkable in this aspect, were not alone in diminutive capacity of brain power. A more extended comparison led to the fact that all the early Tertiary mammals had very small brains.

"The results of this investigation were embodied by the author in a general law of brain-growth in the extinct mammals throughout Tertiary time. This law, briefly stated, was as follows:—

"1. All Tertiary mammals had small brains. 2. There was a gradual increase in the size of the brain during this period. 3. This increase was confined mainly to the cerebral hemispheres or higher portion of the brain. 4. In some groups, the convolutions of the brain have gradually become more complex. 5. In some, the cerebellum and the olfactory lobes have even diminished in size. 6. There is some evidence that the same general law of brain-growth holds good for Birds and Reptiles from the Cretaceous to the present time.[1]

"The author has since continued this line of investigation, and has ascertained that the same general law of brain-growth is true for Birds and Reptiles, from the Jurassic to the present time."

The small size of the brain in early Tertiary mammals will be indicated by an examination of the *Dinocerata* skulls, with the brain in position, shown in Figures 4, 5, 10, and 11.

Prof. Marsh has still further illustrated this most interesting subject by giving in his Monograph figures of the crania of *Limnohyus robustus*, Marsh (Middle Eocene); *Amynodon advenus*, Marsh (Upper Eocene); *Elotherium crassum*, Marsh (Miocene); *Mastodon Americanus*, Cuvier (Pliocene); and *Platygonus compressus*, Le Conte (Pliocene), and many others, showing a well-marked advance in size and complexity of the brain from Eocene times to the present period in the Mammalia.

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[1] See Silliman's American Journal of Science, vol. viii. p. 66, July, 1874; and vol. xii. p. 61, July, 1876; also Odontornithes, p. 10, 1880.

The Vertebræ.—The cervical vertebræ of the *Dinocerata* in their main characters resemble those of the Proboscidians. The atlas and axis are somewhat similar to those of the Elephant. The rest of the cervicals (Figs. 12 and 13) are proportionally longer. The entire neck was about one-third longer than in the Elephant, thus rendering a proboscis unnecessary, as the head could readily reach the ground. All the præsacral vertebræ, behind the atlas and axis, have the articular faces of the centra nearly flat, as in the typical Proboscidians.

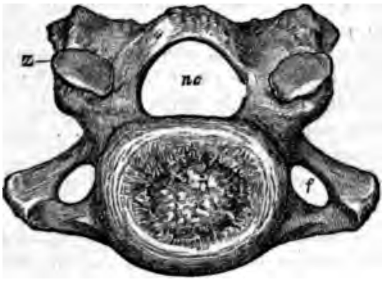

FIG. 12.—Cervical vertebra of *Tinoceras grande*, Marsh; front view, one-fourth natural size. *nc*, neural canal; *z*, anterior zygapophysis; *f*, lateral foramen; *z'*, posterior zygapophysis.

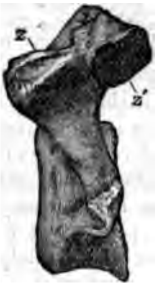

FIG. 13.—Side view of the same vertebra. Letters as in Fig. 12.

"The trunk-vertebræ in the *Dinocerata* are proportionally longer than those in the cervical region. The articular faces of the centra are likewise nearly flat, most of them being distinctly concave (Figs. 14 and 15).

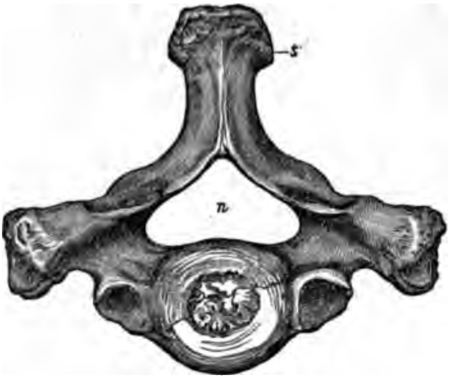

FIG. 14.—Front view of second dorsal vertebra of *Dinoceras mirabile*, Marsh. *n*, neural canal; *s*, neural spine; *z'*, posterior zygapophysis.

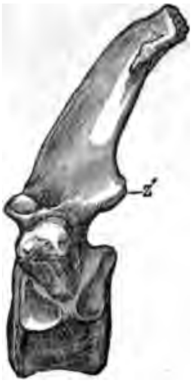

FIG. 15.—Side view of the same vertebra.

The Fore-limbs.—The limb-bones in the *Dinocerata* are nearly or quite solid, and this is true of all the skeleton, a portion of the skull alone excepted. The fore-limbs have a general resemblance to those of Proboscidians. The fore-foot is larger than the hind one in all the *Dinocerata.* The bones comprising it are comparatively short and massive. There were five well-developed digits, as in Proboscidians, but the carpal bones were interlocked with the metacarpals as in the Perissodactyles. The general appearance of the fore-foot in *Dinoceras mirabile* is well shown in Fig. 16. The hind-foot is represented in Fig. 17. The feet were plantigrade as in the Elephant.

"There are eight separate carpal bones in the fore-foot of all the *Dinocerata*, and a ninth, the central bone, may be separate in very young animals, and, in adults, either lost or consolidated with the scaphoid, or the trapezoid. . . . . The metacarpal bones are short and robust. . . . . The phalanges in the fore-foot are very short, and comparatively small. Sternal bones are preserved in a number of individuals of the *Dinocerata* in the Yale Museum, but the entire series in any one individual has not been recovered. . . . . The most marked character of these bones is that they are flat and horizontal, as in the Artiodactyles, and not vertical, as in the Proboscidians, and the Perissodactyles."

The pelvis has a general resemblance to that of the Elephant. The ilia were widely expanded, as in that animal. There are four sacral vertebræ.

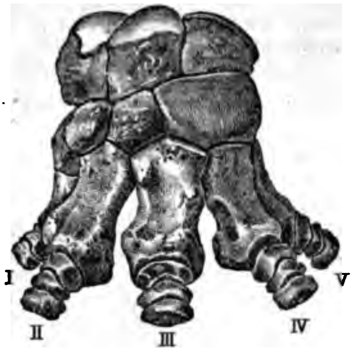

FIG. 16.—Left fore-foot of *Dinoceras mirabile*, Marsh.

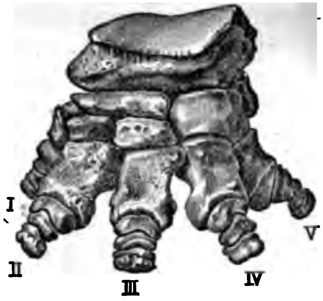

FIG. 17.—Left hind-foot of the same. Both figures are one-fifth natural size.

The Hind Limbs.—"The hind limbs of the *Dinocerata* have a general resemblance to those of Proboscidians, but the bones composing them are comparatively shorter, and more robust. When the animal was standing at rest, the posterior limb formed a strong and nearly vertical column.

"The hind feet were considerably smaller than those in front. . . . . There were five digits, as in the Proboscidians, and the axis of the foot was through the third, or middle, digit.

"There are seven well-developed tarsal bones in the *Dinocerata*, and their relative position in the hind foot is seen in Fig. 17. . . . . An eighth tarsal bone, the tibiale, appears to have been present.

"The astragalus in the *Dinocerata* considerably resembles that of the Elephant, the bone being, as in that animal, very short, along the axis of the leg and foot.

"The calcaneum is short, and comparatively more robust than in the Elephant. As in that animal, it is strongly tuberculated below, where, during life, it doubtless supported a thick pad, resting on the ground."

Restorations.—"In the restoration of *Dinoceras mirabile*, the remains of the type specimen of the species, a fully adult, but not old individual, have been used for the more important parts, and the remaining portions taken from other individuals. This restoration is one-eighth natural size.[1] The animal is represented as walking, and the position of the head, and the feet, has been chosen to show, to the best advantage, these portions of the skeleton as they were in life. In this restoration, only those portions are shaded which are represented by actual specimens in the Yale Museum. The parts in outline are wanting, or are so poorly preserved that only their main features can be given with accuracy.

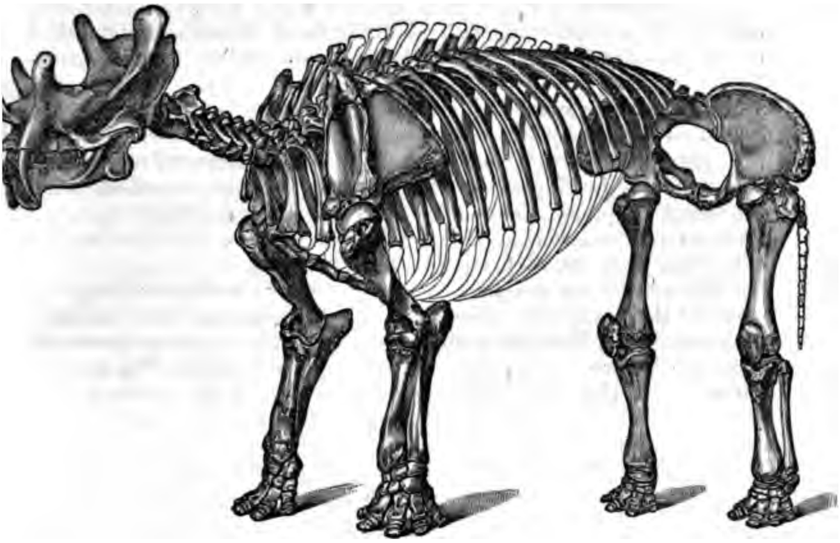

FIG. 18.—Restoration of *Tinoceras ingens*, Marsh. One-thirtieth natural size.

"In the restoration of *Tinoceras ingens*,[2] the animal is represented one-sixth natural size, and standing at rest. The position here chosen shows the massive and majestic form of one of the largest individuals of this remarkable group." A reduced copy of this restoration is given in Fig. 18.

"In comparing *Dinoceras*, as here restored, with some of the largest ungulate mammals of the present day, a certain resemblance to the Rhinoceros on the one hand, and to the Elephant on the other, will naturally suggest itself. In size and proportions, *Dinoceras* was intermediate between these two existing animals, and, in various points of its structure, it resembled the one quite as much as the other. In still other features, *Dinoceras* resembled the Hippopotamus.

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[1] See Prof. Marsh's Monograph, pl. lv.

[2] See *ibid.* pl. lvi.

"In its stature and movements, *Dinoceras* probably resembled the Elephant as much as any other existing form. Its remarkable skull, longer neck, and more bent fore limbs, gave it, however, a very different appearance from any known Proboscidian. The high protuberances, or horn-cores, on the head, the long, trenchant, canine tusks, and the peculiar lower jaw modified for their protection, are features seen together only in this group.

"The neck was long enough to permit the head to reach the ground, and hence a proboscis was quite unnecessary. The horizontal narial opening, the long overhanging nasal bones, and the well-developed turbinal bones, are likewise proof positive against the presence of such an organ. There is some evidence of a thick flexible lip, resembling, perhaps, that of the existing Rhinoceros.

"The remarkably small brain, and the heavy massive limbs, indicate a dull, slow-moving animal, little fitted to withstand marked changes in its environment, and hence it did not survive the alterations of climate with which the Eocene period closed.

"Both the animals chosen for these two restorations were evidently males, as shown by the lofty protuberances, or horn-cores, on the skull, and the powerful canine tusks. In the females, these parts are but feebly developed, as shown in the specimens described in the preceding chapters. The individuals here restored were certainly thrice-armed, and well fitted to protect themselves, and their weaker associates, from any of their Eocene enemies.

"The exact form and nature of the offensive weapons which surmounted the head of the *Dinocerata* cannot, at present, be determined with certainty. That the paired osseous elevations seen on the skull in all the known species of this group did not support the kind of horns seen in the typical Ruminants is evident from their external surface, which lacks the vascular grooves so distinct on the horn-cores of those animals.

"Possibly, the *Dinocerata* may have been armed with horns similar to those seen in the American Antelope (*Antilocapra*), since, in this animal, the horn-cores are even smoother than in the order here described. More probably, however, the bony protuberances on the skull were covered with bosses of thick skin, hard enough to be effective in combat. Evidence of such contests has apparently been recorded in the injuries to the horn-cores of some individuals, received during life. None of the covering of these elevations, or horn-cores, has, of course been preserved; yet a fortunate discovery may, perhaps, reveal their nature by the form of a natural cast, as the eye-ball of the Oreodon is sometimes thus clearly indicated in the fine Miocene matrix which occasionally envelopes these animals.

"The short robust feet of the *Dinocerata* were doubtless covered below with a thick pad, as in the Elephant, since the whole under side of the foot clearly indicates such a protection. No portion of this covering has been preserved in any of the known specimens, and no foot-prints indicating its form have been discovered in the Eocene deposits in which the *Dinocerata* were entombed."

"The size of *Tinoceras ingens*, as he stood in the flesh, was about twelve feet in length, or sixteen measured from the nose to the end of the tail. The height to the top of the back was about six feet and one-half, and the width across the hips about five feet. The weight, judging from that of existing mammals, was about six thousand pounds.

"*Dinoceras mirabile* was about one-fifth smaller. The neck was longer, but, in other respects, the proportions were nearly the same."

In conclusion the author observes:—"Our present knowledge of the Mammalia, living and extinct, clearly indicates that they must go back at least to the Permian. The generalized mammal of that period, or of still earlier time, was probably quite small, and, in many respects, like an Insectivore. This primitive type would naturally possess all the general characters found in later forms in the various orders of mammals.

"This generalized mammal would belong to the group named *Hypotheria* by Huxley, who has laid a sure foundation for investigation in this line of research."

In a carefully compiled synopsis Prof. Marsh enumerates twenty-nine described species of *Dinocerata*, of which seven are assigned to *Dinoceras*, seventeen to *Tinoceras*, and five to *Uintatherium*. It contains a reference to every publication in which they have been respectively described or noticed, with the date of publication and the synonym. It is illustrated with thirty-one woodcuts representing what is known of the species, or of some characteristic point in the cranial structure. This Appendix is most valuable for the student of this interesting group of Ungulates, as it enables him at a glance to find the where and the when of all that has been written relating to them.

Space does not permit us to dwell more fully upon this most attractive Memoir. The subject of the evolution of the Mammalia is so vast, and so full of interest to the palæontologist, as well as to the zoologist, that Prof. Marsh's volume is sure to be taken up by both and studied with the attention it so richly deserves. It is a pattern of completeness, and may serve as a model for other writers to follow. The author modestly observes that his aim has been to make the illustrations tell the main story to the anatomist. "The text," says Prof. Marsh, "may lose its interest and belong to the past, but good figures are of permanent value in all departments of natural science." The author is, we think, to be congratulated upon the excellence of both text, woodcuts and plates, and we earnestly trust that both life and energy may be prolonged to Prof. Marsh, for many years to come, in which to continue this most splendid scientific work.

It may not be without interest to our readers to learn that Prof. Marsh has most generously placed a fine series of casts of skulls and bones of the *Dinocerata* in the Geological Department of the British Museum (Natural History), so that we can now form from their study a very fair idea of these huge Eocene herbivores once so abundant in Central North America.

II.—UNDERSÖKNINGAR ÖFVER BRACHIOPODERNA I SVERGES KRITSYSTEM AF BERNHARD LUNDGREN. Med 3 Taflor i Ljustryck. (Ur Lunds Universitets Årsskrift. t. xx.)

DESCRIPTIONS OF THE BRACHIOPODA IN THE CRETACEOUS ROCKS OF SWEDEN. By BERNHARD LUNDGREN. With Three Photographed Plates. From Lund University Year Book, vol. xx. pp. 72. (Lund, 1885.)

AS an introduction to this valuable monograph, Prof. Lundgren has given a short description of the characters of the Cretaceous rocks of Sweden, which is not without interest to those who study the group in this country. The Swedish Cretaceous strata, as is well known, cover an extensive area in the Province of Skåne, at the south of the peninsula. They have been investigated at various times by such authorities as Angelin, Hebert, Schlüter and others, but owing in part to the thick coating of glacial drift which conceals the underlying Chalk from observation, and in part to the very different aspect which strata of the same geological horizon exhibit in different localities, the relative position of the different beds has not been definitely settled.

According to Prof. Lundgren, the Cretaceous strata of Sweden have peculiar petrographic and palæontological characteristics in each of the three different districts of Kristianstad, Ystad and Malmö. That of Kristianstad, to the north-east of the province, principally consists of *Gruskalk* (that is, of a limestone composed of grains resulting from the breaking up of the shells and tests of molluscs and echinoderms) with in places a mixture of quartz-sand-grains and even occasionally boulders of metamorphic rocks, so that the Gruskalk passes sometimes into a pure sandstone, or even a coarse conglomerate. Flints are not abundant; they occur either in thin beds or nodules, and they are always of a speckled white, and never black or greenish-black as in the chalk of the Malmö district. In places the gneissoid rocks, which formed the sea-bed on which the Gruskalk was deposited, are exposed with their surfaces covered with naturally-attached Polyzoa, Spondylus, etc. The Kristianstad deposit is clearly of a shallow-water character. Two palæontological divisions can be recognized in it; a lower characterized by *Actinocamax subventricosus*, and a higher by *Belemnitella mucronata*. The lower division has only been recognized elsewhere out of Sweden in East Prussia, and it is thought partially to correspond to the German Quadraten-Kreide.

The Ystad district on the extreme south is now separated from that just referred to by a broad gneissoid ridge, which probably existed in Cretaceous times; the boundaries between it and the Malmö district have not been ascertained. The prevailing rocks are incoherent calcareous sandstones with a variable quantity of green grains, whence it is sometimes called a greensand. Subordinate beds of conglomerate, mostly of Silurian slates, are present; but flints are absent. In addition to the same divisions which, as at Kristianstad, are characterized by *A. subventricosus* and *B. mucronata*, there are two others beneath them; one containing *Actinocamax quadratus*, and the other *A. verus*. Borings carried to a depth of 1300 feet have not penetrated through the chalk in this district.

The rocks of the easterly district of Malmö resemble those of Denmark, and may be regarded as their easterly continuation. The beds are of pure white chalk of varying degrees of hardness, and layers and nodules of flint are abundant in it. The flints are black or greyish, but never speckled. The general appearance of the chalk in this district, as the writer can testify, resembles very closely the chalk at Norwich. The Malmö chalk exceeds 600 feet in thickness, and though its petrographic characters are so strikingly different from those of the other districts, the presence in it of the same typical fossil, *Belemnitella mucronata*, shows that it, and the Gruskalk, and sandstones of the other districts, all belong to the same geological horizon of the Skrifkrita, or our Upper Chalk with flints.

In the Malmö district the Skrifkrita or Upper Chalk is overlaid by higher beds, of the Étage Danien or "Newer Chalk," of which three different varieties are described by Prof. Lundgren, who, however, regards them as merely different aspects of the same contemporaneous deposit. The first of these, the Faxoe or coral limestone, is composed largely of corals which appear to have grown *in situ*; it also contains Crustacea (*Dromia*) and Gasteropods. Flints are not present in it. The second is the Limsten or polyzoa-limestone, consisting of entire and fragmentary polyzoa, corals, and other organic remains, which have been rolled and rearranged by currents. It also contains flints. The third variety, Saltholm limestone, is a more or less compact limestone with beds of flint; it is distinguished by its Fishes, Crustacea (*Glyphea*), and the so-called *Ophiomorpha*.

In all these different varieties of the Danien or Newer Chalk *Belemnitella mucronata*[1] and other forms of *Belemnites* are absent; but they all contain two characteristic fossils, *Ananchytes sulcata* and *Terebratula lens*, which are respectively very closely allied to *A. ovata* and *T. carnea* of the Upper Chalk. Lundgren does not think that the correspondence of these Danien beds with the Maestricht Chalk has been satisfactorily proved, since in the latter *B. mucronata* is present, and the genera and species of corals are also different; and he is disposed to accept the suggestion of Schlüter, that they are rather the equivalents of the most recent Cretaceous beds of Westphalia, in which fishes and plants are present, but no Belemnites.

Of the Brachiopoda from the Upper Chalk, only a single new species, a *Lingula*, has been described, but there are 16 new forms from the other horizons. The most prolific brachiopod fauna is in the division with *Actinocamax ventricosus* in the Kristianstad district. Fifty-five species and varieties are enumerated in the accompanying list, of which only a small proportion appears to be common to our English Chalk. The genera represented are *Crania* (13 sp.); *Rhynchonella* (10 sp.); *Terebratula* (12 sp.); *Terebratulina* (6 sp.); *Thecidium* (3 sp.); and *Lingula*, *Waldheimia*, *Trigonosema* and *Terebratella*, each with a single species. Lundgren acknowledges that he has defined the species in a more limited sense than Davidson, and it is quite possible that our great English authority would not entirely indorse the specific value assigned to all the forms here described; still the characters assigned to the species and varieties are very carefully and fully enumerated, and as all the forms are thoroughly and of necessity faithfully illustrated in the accompanying photographed plates, the work will prove of great value in comparing the Cretaceous Brachiopoda of Sweden with those of our own and other countries.

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[1] Lyell has stated that this species occurs in the Faxoe limestone, but the author affirms that it certainly does not occur in this deposit, though it may be found in beds of Secondary, *i.e.* of Glacial origin which overlie it.

G. J. H.

III.—UNDERSÖKNINGAR ÖFVER SILJANSOMRÅDETS TRILOBITSFAUNA AF SV. LEONH. TÖRNQUIST. Med tre Taflor.

AN EXAMINATION OF THE TRILOBITE FAUNA OF THE DISTRICT OF SILJAN. By SV. LEON TÖRNQUIST. With three Plates. 4to. pp. 101.

THIS monograph contains the results of a detailed examination of the Trilobites discovered in the Silurian basin of Siljan in Dalecarlia. In all 113 species and varieties are enumerated, including many new forms, belonging for the most part to very minute types, which have hitherto escaped notice, probably on account of their small dimensions. As a general rule the Trilobites are very fragmentary, and the descriptions mainly rest on their detached heads and pygidia. A tabulated list shows their respective stratigraphical distribution in the series of beds which range from the Phyllograptus-shales up to the Leptæna-Kalk, which the author believes to be relatively slightly older than the Wenlock Shale. The new species are all figured, and the careful manner in which the various forms are described renders this work of special value for comparison to students of this group, as it well illustrates the distribution of the Trilobites in a particular limited area.

G. J. H.

IV.—CONTRIBUTIONS TO THE TERTIARY GEOLOGY AND PALÆONTOLOGY OF THE UNITED STATES. By ANGELO HEILPRIN. 4to. pp. 1–4 (unnumbered) and 1–117. One Plate. (Philadelphia, the Author, 1884.)

THE volume is a prefaced reprint of several independent treatises, viz.—"I. The Tertiary Geology of the Eastern and Southern United States" (Journ. Acad. Nat. Sci. Phil. 1884, 2nd ser. vol. ix. pp. 115–154); "II. On the Relative Ages and Classification of the Post-Eocene Tertiary Deposits of the Atlantic Slope" (Proc. Acad. Nat. Sci. Phil. 1882, vol. xxxiv. pp. 150–186); "III. On the Stratigraphical Evidence afforded by the Tertiary Fossils of the Peninsula

POST-PLIOCENE.			FOREIGN EQUIVALENTS.
Pliocene.	?	?	
Miocene.	Carolinian (Upper Atlantic Miocene.)	Deposits of North and South Carolina ("Sumpter" epoch of Dana).	Diestian ?
	Virginian (Middle Atlantic Miocene.)	Deposits of Virginia, and the newer group in Maryland ("Yorktown" epoch, in part, of Dana).	Probably of the age of the "Second Mediterranean" of the Austrian geologists, and of the faluns of Touraine; Caroni beds of Trinidad; and Miocene of San Domingo, Jamaica, and Cumana ?
	Marylandian (Lower Atlantic Miocene.)	Older Miocene deposits of Maryland, and possibly the lower beds in Virginia ("Yorktown" epoch, in part, of Dana).	Probably (or at least partially) the equivalent of the "First Mediterranean" of the Austrian geologists and of the faluns of Leognan and Saucats.
Oligocene.	Orbitoitic.	Strata characterized by species of *Orbitoides*. Vicksburg beds, Florida nummulitic beds, etc.	Aquitanian. Deposits of Crosara and Castel Gomberto (Vicentin), Oligocene of the Mayence Basin, sands of Fontainebleau, lower limestone of Malta, Fernando beds on Trinidad, Antigua, Chert, St. Bartholomew Oligocene.
Eocene.	Jacksonian.	Jackson beds of Mississippi. "White Limestone" of Alabama.	Barton Clay (Bartonian). Sands of Beauchamp ?
	Claibornian.	Fossiliferous arenaceous deposit of Claiborne, Ala., etc.	Age of the "Calcaire Grossier" of France (Parisian).
	Buhrstone.	Beds below the true Claibornian on the Alabama River, "Chalk Hills" of the southern part of the State, etc. "Siliceous Claiborne" (Hilgard) of Mississippi. Maryland Eocene, in part ?	Londonian ?
	Eo-Lignitic.	Lignite, sands and clays situated at the base of the Tertiary Series in Alabama, etc. Marlborough and Piscataway beds of Maryland ? Shark River deposits of New Jersey.	Thanetian ? Bognor rock ?

of Maryland" (*ibid.*, 1880, vol. xxxii. pp. 20–33); "IV. On the Occurrence of Nummulitic Deposits in Florida, and the Association of *Nummulites* with a Freshwater Fauna" (*ibid.* 1882, vol. xxxiv. pp. 189–193); "V. A Comparison of the Eocene Tertiary Mollusca of the South-Western United States and Western Europe in relation to the Determination of Identical Forms" (*ibid.* 1879, vol. xxxi. pp. 211–216); and "VI. On the Age of the Tejou Rocks of California, and the Occurrence of Ammonitic Remains in Tertiary Deposits" (*ibid.* 1882, vol. xxxiv. pp. 196–214).

In the first of these Mr. Heilprin collects the essence of the scattered literature of, and summarizes his own investigations upon, the Atlantic and Gulf Territories. The deposits prevail over a zone of 25,200 miles wide, skirting the coast from northern New Jersey to Mexico, augmented by the Floridian peninsula and the Mississippi embayment. In the north the beds are mainly incoherent sands (siliceous, calcareous, and glauconitic), clays, and marls, while in the south lithification is common, particularly in the older members. In general, strikes are roughly parallel to the coasts, and the gentle dips seaward. Only slight and simple diastrophism has affected the region since Tertiary deposition was initiated.

The author's conceptions of stratigraphic sequence and equivalence are expressed in the taxonomic table, reprinted on p. 231; the distribution of the several members recognized is approximately shown on a small scale map. In text and map, Hilgard's doubtful reference of the "Grand Gulf" formation to the Miocene is adopted: but the interesting Pliocene or early Quaternary "Port Hudson" is neglected, as is also the Pliocene (?) "Glass Sand" of New Jersey and Long Island. Identification and correlation are essentially palæontologic; the diastrophic and geomorphic phenomena whereby the formations in question must ultimately be coördinated are ignored; and correlation with the western territories is not attempted.

The scope of the subordinate articles is indicated by their titles. Their substance is incorporated in the general discussion.

The volume is unfortunately without index or other conspectus of contents than a list of articles, the data for the discussions are predominantly bibliothecal, the style is verbose, and the map is crude; yet in its assimilative function the leading treatise will prove valuable alike to foreign readers and local investigators. W. J. M.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

I.—March 25, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On the Relationship of *Ulodendron*, Lindley and Hutton, to *Lepidodendron*, Sternberg, *Bothrodendron*, Lindley and Hutton, *Sigillaria*, Brongniart, and *Rhytidodendron*, Boulay." By Robert Kidston, Esq., F.G S.

The author commenced by expressing an opinion that the so-called genus *Ulodendron* of Lindley and Hutton comprised specimens belonging to several species and even to different genera. Unless the outer surface of the bark is well preserved, stems of Clathrarian *Sigillariæ* and *Lepidodendra* are undistinguishable; but species of *Ulodendron* have been in several cases founded on decorticated examples, and distinguished by such characters as the size of the Ulodendroid scar. The three species which have furnished most of the specimens described as *Ulodendron*, and to the description of which the present paper is chiefly devoted, are *Lepidodendron Veltheimianum*, Sternb., *Sigillaria discophora*, König, sp., and *S. Taylori*.

The author first gave an epitome of the views of previous writers on *Ulodendron*; and secondly, described the specimens belonging to the species named that he had been able to examine.

The third part contained the general conclusions as to the nature of *Ulodendron* at which he had arrived. He commenced by defining the four genera *Lepidodendron*, *Lepidophloios*, *Sigillaria*, and *Rhytidodendron*, as distinguished by the characters of their leaf-scars, and showed that *Lepidodendron*, *Sigillaria*, and *Rhytidodendron* occasionally exhibit large scars, arranged in two opposite vertical rows. These are the Ulodendroid scars. They marked, in the author's opinion, the point of attachment of a caducous appendicular organ, which had in a very few cases been found in position. These appendicular organs were probably sessile cones. Details were given, showing the progressive development of the scars, the obliteration of the normal leaf-scars by the appendicular organs, and the branching of Ulodendroid stems.

The concluding portion of the paper contained the synonymy at length and full descriptions of three fossil plants, *Lepidodendron Veltheimianum*, *Sigillaria discophora*, and *S. Taylori*, together with the horizons and localities in which they have been found in Britain. *Bothrodendron* was shown to be a decorticated form of Ulodendroid stem, and *Knorria* a cast of the case of *Lepidodendron*.

2. "On an almost perfect Skeleton of *Rhytina gigas*=*Rhytina Stelleri* ('Steller's sea-cow') obtained by Mr. Robert Damon, F.G.S., from the Pleistocene Peat-deposits on Behring's Island." By Henry Woodward, LL.D., F.R.S., F.G.S.

The author spoke of the interest which palæontologists must always attach to such animals as are either just exterminated, or are now in course of rapid extirpation by man or other agents. He referred to the now rapid destruction of all the larger Mammalia, and expressed his opinion that the African Elephant, the Giraffe, the Bison, and many others, will soon be extirpated unless protected from being hunted to death. The same applies to the Whale- and Seal-fisheries.

He drew attention to a very remarkable order of aquatic animals, the *Sirenia*, formerly classed with the Cetacea by some, with the Walruses and Seals by others, and by De Blainville with the Elephants. He particularly drew attention to the largest of the group, the *Rhytina*, which was seen alive and described by Steller in 1741. It was then confined to two islands (Behring's Island and Copper

Island). In forty years (1780) it was believed to have been entirely extirpated. It was a toothless Herbivore, living along the shore in shallow water, and was easily taken, being without fear of man. Its flesh was good, and it weighed often as much as 3 or 4 tons.

The author then described some of the leading points in the anatomy of *Rhytina*, and indicated some of the characters by which the order is distinguished. He referred to the present wide distribution of the Sirenia:—*Manatus* with three species, namely, *M. latirostris*, occupying the shores of Florida and the West Indies; *M. americanus*, the coasts of Brazil and the great rivers Amazon and Orinoco; *M. senegalensis*, the West Coast of Africa and the rivers Senegal, Congo, etc. *Halicore* with three species, namely, *H. tabernaculi*, the Red Sea and East coast of Africa; *H. dugong*, Bay of Bengal and East Indies; *H. australis*, North and East Australia.

The fossil forms number thirteen genera and twenty-nine species, all limited to England, Holland, Belgium, France, Germany, Austria, Italy, Malta, and Egypt, and to the United States and Jamaica.

The author noticed the dentition of the fossil species, of which *Halitherium* and *Prorastomus* are the two most remarkable types.

Lastly, with regard to the geographical area, occupied at the present day by the Sirenia, the author pointed out that two lines drawn 30° N. and 30° South of the Equator, will embrace all the species now found living. Another line drawn at 60° N. will show between 30° and 60° N. the area occupied by the fossil species.

He looked upon *Rhytina* as a *last surviving* species of the old Tertiary group of Sirenians, and its position as marking an "*outlier*" of the group now swept away. The greater northern extension of the group seems good evidence of the once warmer climate enjoyed by Europe, Asia, and America in the Tertiary epoch.

II.—German Geological Society.

The following is an abstract of a paper "On the Limits of the Zechstein Formation and of the Dyas in General,"[1] by Geh. Hofrath Professor Dr. H. B. Geinitz, etc., read before the German Geological Society in September, 1884.

1. *The Upper Limit of the Zechstein Formation.*—The uppermost member of the Zechstein is defined as the "Plattendolomit" with *Schizodus Schlotheimi* (Gein.), *Aucella Hausmanni* (Goldf.), and a few other rarer fossils; not the overlying Bunterschiefer of Murchison or the so-called upper variegated shales (Z. o. 3) of the maps of the Geological Surveys of Saxony and Prussia. Extensive erosion of the upper beds of the Plattendolomit produces a general discordancy between them and the overlying shales and thin-bedded sandstones; it is only where this is not observable or is observable to only a slight extent that anything like concordancy between them is to be observed. The published works of previous observers (Gutbier, Naumann, von Cotta, and Emmrich) are quoted as establishing these facts. The author then proceeds to describe additional sections

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[1] See Nova Acta Acad. Leopoldina xxi. 1885.

which he examined during last year, in company with Herr Dittmarsch. Very clear sectional drawings of six of these are included in the paper, two of which represent sections near Meerane in Saxony. These, with the descriptions of them, agree in character with those noticed by the translator, in the Quart. Journ. of the Geol. Soc. vol. xl. p. 391, and this agreement is pointed out.

The theory advocated by some writers, that "the circulation of water between the strata of the Plattendolomit has, by internal erosion of the beds, produced cavities into which the overlying beds have sunk," is criticized and shown to be inconsistent with the observed facts.

The author next points out that unless we are to class the whole of the Bunter with the Zechstein, against which there are insuperable objections on palæontological grounds, it is impossible (and the impossibility is acknowledged by his colleagues of the Geological Survey) to draw any boundary-line whatever between the Zechstein and the Bunter. The fossil-evidence recently found by the author in the Meerane district in the regularly stratified beds of sandstone in the limestone quarry next the village of Crotenleite, in a position less than a mètre above the eroded surface of the Plattendolomit,[1] is next described, and the close resemblance of the numerous Saurian footprints discovered by the author last summer in that locality with those of *Chirosaurus Barthi* and *Chirotherium Geinitzi* in the University Museum at Jena and elsewhere is pointed out. As in company with the latter there was found a somewhat larger and coarser but otherwise similar form to *Rhizocorallium jenense* of the lower Wellenkalk, so here, immediately above the Plattendolomit, the same association of undoubted Triassic forms was met with. In addition to these, the author also mentions the occurrence of a few horseshoe-shaped reliefs on the bedding-planes of the sandstones, which he considers to be vegetable-remains, and these bear the closest resemblance to certain forms which have been described by Koch and E. Schmid from the Bunter Sandstone of Jena. [Those who know the district about Jena will see the force of this comparison.] These remains are now open to the inspection of geologists in the Dresden Museum. "Though these are as yet so sparingly met with (says Geinitz), yet they prove that the variegated shaly sandstones (Z. o. 3) belong to the Bunter and not to the Zechstein."

"In other districts, where also the lower members of the Zechstein are developed, local disturbances of the original stratification have occurred, partly through subsidences of the Plattendolomit in consequence of the solution of gypsum and rock-salt, partly through the elevation of the strata in consequence of the gradual conversion of anhydrite into gypsum. Excellent examples of this occur in the neighbourhood of Gera, and at Pösneck and Oppurg in Thüringen; yet in all these cases a similar unconformable order of deposition of the lower Röth (the lowermost Bunter strata) upon the upper Zechstein is repeated." These instances are described in detail in the paper, as are also others at Gumpelstadt, N.E. of Salzungen, and in the neighbourhood of the Lower Warth. In the latter locality the red shales and thin-bedded sandstones are stratified around highly inclined strata of Plattendolomit and a reef of Rauchwacke (Middle Zechstein). The relation of the Bunter to the Zechstein as it is exhibited at Göpelskuppe near Eisenach is also noticed, and reference is made to the accurate demonstration of it by J. G. Bornemann (Jahrb. d. k. preuss. geolog. Landesanstalt, 1883), as well as the description of it in Quart. Journ. Geol. Soc. vol. xl. p. 303 *et seq.* by the translator.

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[1] Comp. Geol. Mag. December, 1884, where a quotation is made from a letter of Geinitz on this subject.

From the evidence cited, the author concludes that the so-called upper variegated shales and thin sandstones of the Saxon and Prussian maps, which correspond to the Bunterschiefer of Murchison, belong not to the Zechstein, but to the Bunter Sandstone, so that "an important member of the Permian Formation (in Murchison's sense) is taken away, and there remains of that Palæozoic Trias, which that deceased author defined as his Permian, only a dual system or Dyas."

2. *The Lower Limit of the Zechstein Formation.*—Wherever a complete development of the Marine Zechstein Formation is exhibited, the Weissliegende (Grauliegende, Zechstein Conglomerate of Beyrich) forms the lowest member. This stratum, varying in thickness from a few centimètres to several mètres, contains an extraordinary marine fauna, among which are found as characteristic species, *Productus Cancrini* (de Vern.), *Strophalosia Leplayi* (Gein.), *Rhynchonella Geinitzi* (de Vern.), and *Pecten sericeus* (de Vern.). Thus the Weissliegende is distinguished principally from the Rothliegende, the nature of which is determined by association of the littoral character of its sedimentary materials with eruptive rocks. Freiesleben, Dr. Liebe of Gera, Dr. Senft of Eisenach, and other writers are quoted in support of this view.

The position of the upper Rothliegende as a lateral equivalent in some localities of the true Middle and Lower Zechstein is touched upon, and its occurrence in relation to the latter on the north-west side of the Thüringerwald is pointed out (see Quart. Journ. Geol. Soc. *loc. cit.*, and Senft, Zeitschr. d. deutsch. Geol. Gesellsch. Bd. x. p. 333, Taf. ix. fig. 9). "The opponents of this view," adds Geinitz, "have hitherto offered no explanation of the facts observed."

3. *The Lower Boundary of the Dyas in General.*—Where the massive grey conglomerate of the Lower Rothliegende, or the anteporphyritic stage of Naumann, overlies the Coal-measures unconformably, as it does in the district of Zwickau and other places in the basin of the Erzgebirge, the boundary between the Dyas and the Carboniferous appears very clearly defined. In other places, as in the Plauenscher Grund near Dresden, where the discordancy is less pronounced, the grey conglomerate zone still rests upon the eroded surfaces of the previously indurated Coal-measures, in such a manner as to remind us of the way in which the eroded strata of the Plattendolomit are overlain by the thin strata of the Bunter. In some places the massive Brandschiefer (bituminous shales) overlie the

Coal-measures, and contain even feeble black seams of coal. In such cases the boundary is well indicated by the presence of the characteristic flora and fauna of the Lower Rothliegende, *Walchia piniformis* (Schl.), *W. filiciformis* (Schl.), *Odontopteris obtusiloba* (Naum.), *Callipteris conferta* (Stbg.), *Calamites gigas* (Bgt.), and other characteristic plant-forms, or by such characteristic fish-remains as *Acanthodes gracilis* (Röm.), *Xenacanthus Decheni* (Beyr.), *Palæoniscus angustus* (Ag.) and others.

4. *On the Integral Character* (Selbständigkeit) *of the Dyas as a "Terrain" or "System"* (newer nomenclature of the International Geological Commission).

"We are now pretty generally convinced from such evidence as is described above that the strata of the Dyas (or Permian) mark the close of the Palæozoic series of formations, as was admitted, in fact, by the celebrated Sir R. I. Murchison; it remains however still a question whether the Dyas or Permian shall maintain its position as an independent system, or should be subordinated to the Carboniferous. perhaps under the name of Post-Carboniferous ("Post-carbon"). This was not definitely settled at the sittings of the International Commission for Geological Nomenclature, etc., at Bologna in 1883, and the question remains to be decided at the next International Congress at Berlin.

"For a satisfactory answer to the question it must be referred primarily to the German geologists, since it is in the German area that the greatest and most significant changes took place in the Dyas period, especially in the construction of continental deposits (Festlandbildungen); the views of the Russian, English, and North American geologists have also to be considered, since in those countries discovery has followed quickly upon discovery in the region of the Dyas in most recent times.

"The richest fauna and flora of the Dyas is certainly to be seen in the Royal Mineralogical Museum in Dresden, where perhaps geological *confrères* will be convinced that even from a palæontological point of view our Dyas deserves the same recognition as an independent Terrain or System, as the Devonian in comparison with the Silurian, and that notwithstanding the fact that several species pass upwards from the Silurian to the Devonian." A. Irving.

CORRESPONDENCE.

NOTE ON SOME SIWALIK BONES ERRONEOUSLY REFERRED TO A STRUTHIOID (*DROMÆUS* (?) *SIVALENSIS*, LYD.).

Sir,—In examining the collection of Mammalian remains in the British Museum for the purpose of cataloguing, I have come across certain specimens from the Siwalik Hills, which have convinced me that the phalangeals described and figured in the "Palæontologia Indica" (Mem. Geol. Surv. India), ser. 10, vol. iii. pp. 145, 146, pl. xiv. figs. 2, 4, 5, 6 (1884), as belonging to a Struthioid, and named *Dromæus* (?) *sivalensis*, are not Avian at all, but belong to one of the lateral digits of the fore-foot of an Artiodactyle Ungulate allied to the *Hippopotamus*. The genus *Dromæus* must therefore be expunged from the Siwalik fauna.

I regret having made this unfortunate misidentification; but am glad to take this early opportunity of correcting it. A note to the same effect will appear in the Introduction to the volume of the "Palæontologia Indica," quoted above, on its completion.

R. LYDEKKER.

SUBTERRANEAN CONTOURING ON GEOLOGICAL MAPS.

SIR,—The notice in your March number, by my friend Professor Benjamin Smith Lyman, of Northampton, Mass., regarding this means of expressing the underground configuration of stratified deposits would, I venture to think, have attracted wider attention if it had dealt as fully with the manner of construction as it does with the results to be gained.

A long acquaintance with Professor Lyman's own use of this system in the number of beautifully constructed maps which he has produced of Japanese and other geological regions must be my excuse for pointing out that, while the employment of the system on a large scale by another American geologist (in the Pennsylvania anthracite coalfield) is certainly evidence in his favour, the important circumstances stated in the second sentence quoted from Mr. Ashburner's report have an essential bearing upon the usefulness of these contour lines. The quotation reads thus:—"The data which are available for the construction of these maps are very extensive and very accurate." This beings so, few will doubt that in such a case plans showing true underground contours of coal beds, etc., would be most valuable charts for the guidance of all kinds of mining operations. But granting this involves the consequence that, where the data are neither extensive nor accurate, the results will be hypothetical and may be even largely based upon the safety of assertions which there is no evidence to contravene, albeit there may still be ample room for doubt.

The forms and curvatures assumed by contorted strata varying infinitely, it seems to me we may speculate upon, but cannot predict, the continuity of any conditions at depths beyond the reach of direct observation. We may trace an ellipsoid formed at the surface by the outcrop of a synclinal basin, but without further information we can scarcely foretell whether the interior rocks are, or are not, folded again and again into anticlinal and synclinal curves, overfolded or faulted, thinned away or crushed out.

If what we call contortions had as uniform proportions as basins, saucers, spoons or even casks, from any section of which something might be presumed regarding the size and shape of other portions concealed, the theory of these contour lines would be complete; but as neither the shape nor size of a contortion has relation to any standard, I do not see the advisability of laying down upon ordinary geological maps, with the semblance of accuracy, what are merely *possible positions*, amongst many others at which a concealed stratum might be found.

This element of uncertainty, it is true, affects the absolute accuracy of many geological sections, if not of most—in an unavoidable way, for which reason it would be wiser to reduce than to multiply sources of error.

A geological map is in a sense pictorial, and the more so the more easily understood: competing interests destroy such pictures as contain them by creating confusion; hence, is it not better to struggle on with existing difficulties in order to convey surface observations intelligibly, than seek to overlay our maps with a complex of subterraneous assertions—save where necessity and data may both exist, as in the case of mining plans for special purposes.

Supplementing facts with fancies may possess a charm, but the tendency is dangerously apt to degenerate, or lead us into paths which geological observers of orthodox principles are as yet not imperatively called upon to tread.

Lest these remarks should be considered captious, let me express a hope that Professor Lyman will further favour your readers with information as to how the positions for contours may be accurately ascertained at depths far removed from observation, amongst highly contorted or disturbed strata? And also as to whether he would advise the use of distinct plans on which to record the positions of the contours at the various depths, when ascertained.

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Kingstown, *March* 11*th*, 1885.

THE CLASSIFICATION OF THE JURASSIC SYSTEM.

Sir,—If Mr. Jukes-Browne is satisfied with the argument that because a lithological change does take place, in England, France and Germany, about the line of division between the Cornbrash and Oxfordian, therefore this is a good line of separation between Middle and Upper Jurassics, and one with which most English geologists will be satisfied, I fear it is useless for me to argue further. The statement about the lithological change is true in a certain sense, but it is one of those unscientific half-truths that ignore the main facts. Amongst the facts ignored in this case are the following: The lithological change in Germany from the argillaceous beds of the Brown Jura below to the calcareous strata of the White Jura above is precisely the reverse of that which takes place in North-Western France and England, and the horizon where the change takes place is not the same, in fact the two changes have no connection with each other. So purely local are the lithological conditions on which Mr. Jukes-Browne relies that the argillaceous Upper Jurassics of England and North-Western France are represented even in Central France by calcareous beds.

I did not attempt to enter into the classification of minor subdivisions like the Lower Calcareous Grit. But when Mr. Jukes-

Browne calls attention to my omission to mention this band, he must have overlooked the circumstance that he has forgotten to notice the far more important Calcarian which intervenes between the Oxfordian and the Cornbrash, and which is one of the best known and most widely spread subdivisions of the Jurassic system.

March 14*th*, 1885. W. T. Blanford.

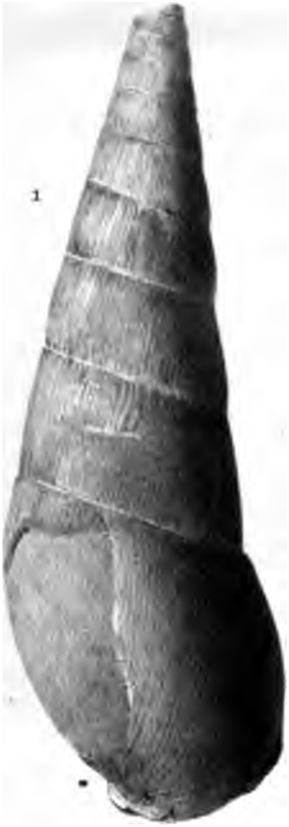
GEOLOGICAL AGE OF THE ROCKY MOUNTAINS.

Sir,—A recent conversation with Dr. Hicks induces me to send you the following record of the results of a short ramble in the Rocky Mountains, which I trust you may deem of sufficient importance to insert in your Magazine.

On a much-to-be-remembered morning on the 11th of last September, Professor Selwyn and Dr. G. M. Dawson of the Canadian Geological Survey, with several other brothers of the hammer, left the cars of the Canadian Pacific Railway at Stephen, for a walk down the track into British Columbia. Passing the picturesque little lake on the summit of the Kicking Horse Pass, between 5000 and 6000 feet above sea-level, the rocks on the right hand of the track were carefully examined for any indication of their age. They consisted for the most part of a series of almost vertical calcareous and quartzite beds, followed by greenish slates and were varied in colour, blue, white and green predominating. Though supposed to be altered Devonian, yet we failed to obtain any fossil evidence to determine this point. After however crossing the high trestle-bridge spanning the torrent which gives its name to the pass, we were more fortunate, and found sufficient evidence whereby the age of these beds could be clearly defined. Remaining behind the rest of the party, my attention was attracted to a greenish micaceous slab of rock dipping at a high angle to the east, bearing on its face those fucoidal markings, or worm-tracks (?), so abundant in the Ilfracombe beds in North Devon, and on detaching some of these, I soon saw other and more important black patches, the organic nature of which there could not be any doubt about. These at first sight were considered to be the shields of Trilobites. Proceeding onwards about 62 yards on the same side, a dense blue calcareous band was found almost vertical about six inches thick divided from another of the same kind about seven inches thick by a parting of greenish shale; both these were full of organisms. On showing them to Prof. Boyd Dawkins and others, they were at once pronounced to be Primordial.

Since my return home, Dr. Hicks has examined my specimens, and states that they represent a Menevian fauna, and that the micaceous rock contains lime and is detrital, with the tail of a *Paradoxides* on its surface, whilst the dense blue calcareous bands have abundant fragments of *Paradoxides*, *Conocoryphe* and other allied forms. This fact is of value, as it proves that a Primordial zone exists north of the 49th parallel of latitude, and somewhere between the 116th and 117th parallels of longitude, a fact which has been, I believe, hitherto denied or at least unproved. H. H. Winwood.

Bath, *April* 17, 1885.



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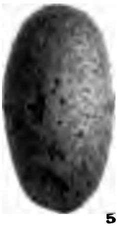

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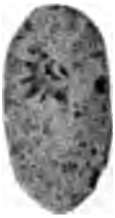

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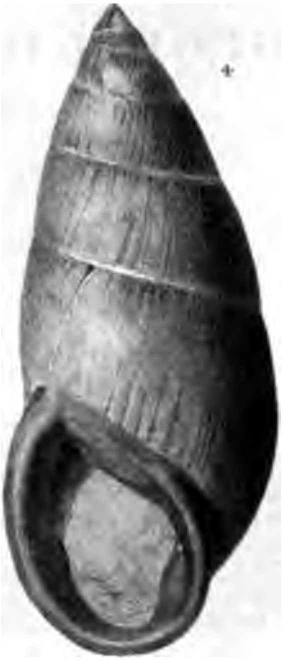

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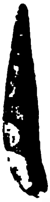

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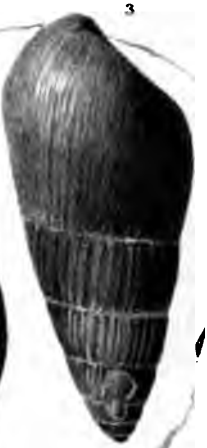

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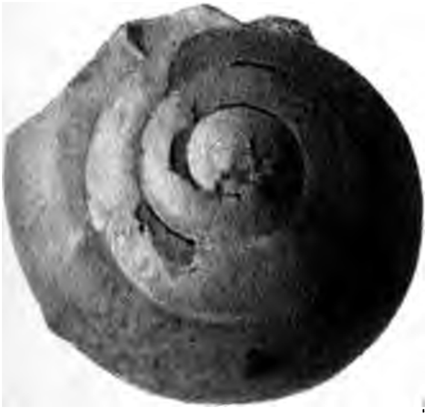

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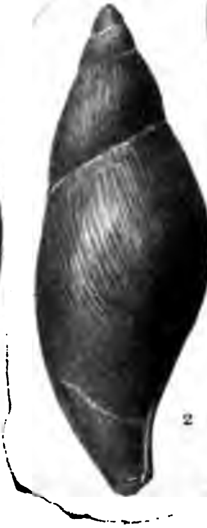

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Land-Shells from the Bembridge Limestone, Isle of Wight.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. II.

No. VI.—JUNE, 1885.

ORIGINAL ARTICLES.

I.—On the Land Mollusca of the Eocenes.

By J. Starkie Gardner, F.L.S., F.G.S., etc.

(PLATE VI.)

THE distribution of land-mollusca still remains one of the most perplexing of the problems to be solved by the geologist. Sir Charles Lyell seems to have been especially struck with their capricious distribution, particularly in Madeira. The facts are still substantially as stated in the tenth edition of his "Principles of Geology," for Mr. Leacock, in showing me the results of many years collecting in Madeira, observed that his researches had not modified them in any important particulars. Nearly all the species are peculiar to the Madeira Archipelago, and the remarkable fact about their distribution is that, though there are 56 species in Madeira proper, and 42 in Porto Santo, only 12 are common to both islands, though in sight of each other. Still more unaccountable it seems, that of 19 species found on the Dezertas, three barren rocks which appear but little detached from the main island, only 12 are common to Madeira, and even each of these islets has species and varieties peculiar to itself. But two species of land-shells are in fact common to Madeira, the Dezertas and Porto Santo. Sir Charles Lyell infers the great antiquity of the Archipelago from this, contrasting it with the far more extensive group of the British Isles, numbering 200 islands, not one of which have yet developed peculiar species. The fact that such narrow seas have sufficed to keep the land-mollusca distinct conclusively proves, in his opinion, that they have no ready means of dispersal, and that their passage across even the narrowest sea must be of such extraordinary rarity that the possibility need hardly be taken into account. The presence of the same species throughout the whole of the British Islands is thus the strongest argument in favour of their having been joined together and to Europe at a very recent date.

Turning to that most fascinating book by Mr. Wallace, "Island Life," in which all possible arguments are arrayed to support the theory of the Permanence of Continents, we cannot help remarking how frequently the land-mollusca are opposed to other evidence, and how, when the distribution of the rest of a fauna can be satisfactorily accounted for, these crop up in contradiction. The present arrangement of land and water can be made to suffice for the distribution of such recently developed things as the existing species of mammals, birds, and butterflies; but the far more ancient families of land-mollusca, at least, seem to have been in possession of their present habitats from the most remote times. I find in "Island Life" that the Azores are stated to possess 69 species, 32 being peculiar, though with a general European facies. A fourth of the land-shells of Bermuda are peculiar, including one genus, while most of the remainder are found in the West Indies and American mainland. The Galapagos Isles possess about 20 species, most of them peculiar. St. Helena has 29, 20 of which are truly indigenous, two of them, *Bulimi*, resembling Brazilian types. The land-shells of the Sandwich Islands number between 300 and 400 species, and 30 genera, three-fourths peculiar; the large sub-family Achatinellinæ, with 14 genera, being entirely confined to the Sandwich Isles, and the genera of Auriculidæ only met with there and in Australia, China, Bourbon, Cuba, and the West Indies. About two-thirds of the land-shells of the Seychelles are peculiar, most being Indian forms, and some like those of Madagascar.

Such examples may be multiplied if we look into Woodward's Manual of the Mollusca. The author of this work is profoundly impressed with the belief that many of the Oceanic Islands are relics of lands that have disappeared. The mollusca of St. Helena especially indicate a closer geographical alliance between the east of South America, than now holds. The presence of several species of old-world genera in the Columbian region, which are wanting in North America, implies a land connection at some very remote period across the Atlantic in temperate latitudes. Two genera, *Anastoma* and *Megaspira*, now peculiar to Brazil, inhabited France during the Eocene. There is nothing in these facts to support the extreme views of the Permanence of Continents, advocated by Wallace; and taken in connection with the observations of such writers as Sir Joseph Hooker and many other botanists, there is such an array of at least *prima facie* evidence against them, which has not been explained away, that they must be held as far indeed from generally acceptable to geologists.

The re-examination[1] of the Eocene land and freshwater fossil shells, which I propose to undertake, will I am convinced present some very curious problems in connection with this subject. The progress of science has moreover rendered some revision necessary, and though Professor Sandberger has to a great extent already effected this, his work is in German, and the British species are mixed up in it with a large number of others.

As the first instalment, I have selected the group of land-shells of the Bembridge and Headon limestones of the Isle of Wight, which, from their size, number, and splendid preservation, probably form the most important assemblage of the kind from any rocks of similar age.

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[1] Nearly all the species have been described for the Palæontographical Society by Mr. F. Edwards, 1852.

Fam. Buliminæ.[1]

Bulimus (Amphidromus) ellipticus,[2] Sby. sp. 1822. Plate VI. Figs. 3 and 4.

The adult shell is sub-perforate?, sinistral, oblong-ovate, bulimiform, composed of 8 whorls.

The general form of the shell is that of a pupa, or chrysalis, the penultimate whorl being almost of the same diameter as the body-whorl. The apex is blunt. The whorls are at first more than twice as wide as high, the fourth whorl in descending is in diameter twice its height, the penultimate whorl in the specimen figured is 18 mm. high against 31 mm. in diameter, and the body-whorl 42 mm. high, with a diameter of 33 mm. All are irregularly tumid, bulging most towards the lower suture. The test is thin. There are two varieties of ribs, one coarse, with a millimètre interval between each, the other fine, in which case 3 ribs occupy one millimètre; the former variety is the commoner, and, though I have not remarked both occurring on the same individual, there are often very fine lines or ribs in the intervals between the coarse ones. The suture is very narrow, but defined. The aperture is ovate, sub-auricular, angular above, its precise form being difficult to describe in words. The peristome is continuous, thickened, and reflected, the columellar lip being a little broader and united to the outer by a thickened callus. The columella is slightly convoluted, and the columellar region lightly excavated. The average length of the full-grown shell is 85 millimètres, or a little over 3¼ inches, and this seems rarely if ever to have been exceeded.

The young are conical, with the last whorl subangular, shells of 2 centimètres in length having a spiral angle of about 55°, which diminishes to about 45° when the length is doubled. The aperture is semi-lunar or a little like an inverted comma, and the lips thin and sharp.

Casts of the young are very abundant in places, far more so than of the adults. Associated with them in still greater abundance are oviform bodies (Plate VI. Fig. 5), variable, but the great majority of which are under 2½ to 3 centim. in length and to 16 mm. in diameter. They are equal and rounded at both ends, with the sides flattened. When not merely casts, they are seen to be enveloped with a thin calcareous shell of rugged texture. They are supposed to be eggs or cocoons, and are sometimes hollow, or partly filled with arragonite, but in general they are casts, with one end free, and the other broken, and adhering to the matrix, as if the animal had effected its escape. Several of the most promising have been slit for me, and are filled with infiltrated granular limestone and arragonite, without betraying any outline of their former living occupant. Their association in such abundance with land-shells, and especially with the young of *Bulimus*, suggests that they may not improbably have been the eggs of the latter. Many *Bulimi* lay eggs of even larger size; but the only examples in the British Museum are eggs of species with relatively very large body-whorls. I have so far not been able to obtain information as to the form of egg laid by the living species of the *Amphidromus* section of the genus. The eggs, if such, are certainly very large in proportion to even the fullest grown adult; but they might have passed, for the internal mould of the body-whorl is 19 millim. across, and the eggs at their greatest diameter but 15 or 16 externally. The recent eggs of the large *Bulimi*, where there is ample space in the body-whorl, are regularly oval; but in these fossils the sides are perfectly straight, and this peculiarity rather favours the assumption that they may really be the eggs of the cylindrical-shelled *Bulimus*, especially as none of the fry of this species are ever found of smaller diameter than the supposed eggs. The size of the egg in living *Pulmonates* bears no settled relation to the size of the shell. The texture of the shell is rugged, but in all the recent eggs I have seen it is smooth. The question cannot, however, be definitely settled until further observations are made.

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[1] That part of the genus to which our fossils belong was separated into a genus *Cochlostyla*, by Férussac in 1819. The name, literally column-shells, indicates sufficiently their general form. The true *Bulimus* has few whorls, the body-whorl being very large and at least equalling in length all the rest of the spire. *Amphidromus* is a smaller group or sub-genus of closely allied species usually sinistral. These subdivisions seem useful in so enormous a genus.

[2] All the species, unless otherwise stated, are described in F. E. Edwards' monograph on the Eocene Mollusca, in the Palæontographical Society's volume for 1852, where the bibliography of the species is detailed at length. Most of them are re-described in Sandberger's Land und Süsswasser Conchylien, Wiesbaden, 1870-75.

Internal moulds of *Bulimus* were formerly found abundantly in the Bembridge Limestone at Sconce. Fine specimens with the shell replaced by carbonate of lime were always rare and of some value,[1] being among the handsomest of our many fine Eocene mollusca. Though the horizon of the species is the Bembridge Limestone, it must have existed throughout the whole of our sub-tropical Eocene period, for part of a shell from the London Clay is figured by Mr. Edwards, and he has specimens from the Middle Headon of Brockenhurst and Hordwell, as well as the Upper Headon of Headon Hill. The National Collection is very rich, comprising at least a dozen fine specimens of the adult shell.

The species appears to be extinct, but one very closely allied, *B. chloris*, Reeve, is a native of the Philippines, and there are many others, as *B. perversus*, of the same group inhabiting the same region. *B. chloris* is a bright yellow shell, somewhat smaller than ours, but so closely resembling it in all other respects, that we are fully justified, in believing that ours is an ancestral form, or genetically connected. Sandberger compares it with *B. palaceus*, v. d. Busch, and *B. Winteri*, Pf., from Java. No species resembling it occurs in other regions, and the group, which is very distinct, is, as already stated, separated under the sub-generic name *Amphidromus*.

BULIMUS (AMPHIDROMUS) LÆVOLONGUS, *Boubée*, 1844. Pl. VI. Fig. 1.

Bull. Soc. Géol. i. ser. 1, p. 213, M. de Serres, Ann. des Sciences Nat. 1844, p. 180, pl. xii. fig. 9.
Sandberger. die Susswasser-Conchyl. 1870-75, p. 287, pl. xvi. fig. 7.

The introduction of the present species into our Eocene fauna is based on a unique specimen said to be from Sconce, and recently acquired for the National Collection.

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[1] 20*s*. seems to have been an established price.

The shell is regularly spiral, and tapers gradually. The extremity is broken, but, supposing, as seems probable, that the spire was continued at the same angle, and allowing that the apex was as obtuse relatively as in the last species, the total length must have reached 130 mms., or more than five inches. The spiral angle is about 18° and the length preserved of the shell 106 mm., comprising 10 whorls. The whorls towards the apex are more than twice as wide as high, the last but two being exactly twice, the penultimate whorl 17 mm. high, to 30 mm. diameter along the inferior suture, and the body-whorl 10 mm. high and 30 mm. in greatest diameter. The whorls are slightly convex and the suture slight. The whole is so finely striated in the direction of the axis, that 4 striæ occupy only 1 mm. The aperture is invisible, being imbedded in the matrix. The peristome was evidently much reflected, but has been chipped away unfortunately, through ignorance of its form. The shell has been replaced by thin, translucent arragonite, and is of a peculiar pale-yellow, suggesting palpably that traces of the original colouring yet remain.

Though evidently allied to *B. elliptica*, the characters are altogether so peculiar, that it has been separated specifically. It departs more widely than the last from any existing species.

The specimen described was purchased from Mr. Gregory as a Bembridge-Limestone fossil, and the matrix has the characters of this limestone. In the South of France it occurs in the Palæotherium-limestone of Villeneuve and Mas Saintes Puelles, and is not rare.

The group *Amphidromus* is confined within well-defined limits—the Philippines, Timor, Celebes, the Malayan Peninsula, and southernmost China, and an outlier in the Eastern Himalayas.[1] Of 13 species, 8 are persistently sinistral, but individuals among the remainder are sometimes dextral.

In the luxuriant and open forests of the Philippines, the vegetation and climate combine to favour the growth of arboreal species, and the genus is represented in prolific splendour. "Mr. Cuming must have truly felt like one transported to the fabled gardens of the Hesperides, when beholding the lofty trees of these sunny isles laden with snails of such magnificent proportions. Aladdin, in the Arabian tale, could not, surely, have contemplated the rich clusters of vari-coloured fruit in the garden of the African magician with more astonishment, nor probably gathered it with more avidity."[2] The animal in the Philippines is uniformly of a sombre olivaceous brown, and dwells in family groups, as it were, among the shady foliage of the branches. An observation strikingly in accord with the arrangement of the fossils is that out of a group of some dozen living specimens, not more than three or four will be found in an adult state, with the lip of the shell reflected.

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[1] Preussische Expedition nach Ost-Asien, Zoologische Theil, vol. ii. E. von Martens, 1867.

[2] Reeve, Conchologia Iconica, 1849, vol. v. p. 1.

I have not, as I have already mentioned, been able to come across any specimens or account of the eggs of the group of *Amphidromus*. The large eggs of the true *Bulimus* are of very firm consistence, and translucent as alabaster. Reeve describes a soft-shelled egg, like that of a snake, as being deposited in little clusters on the trees, between two leaves, which the animal curls up one on another as a receptacle for their protection. Woodward mentions that one of the largest species deposits its calcareous eggs among dead leaves.

Fam. OLEACINIDÆ.

GLANDINA COSTELLATA, Sowerby, sp. Plate VI. Fig. 2.

Syn. *Achatina costellata*, Edwards, Eocene Mollusca, Order Pulmonata, p. 75, 1852.

The shell is cylindrical, fusiform, dextral, imperforate, composed of 6 whorls; the aperture narrow and elliptical. The ultimate whorl or nucleus is obtuse, but the general form of the apex is acute. The whorls forming the spire are wider than high, the 4th whorl in the figured specimen measuring 5 mm. in height, with 8 mm. as the diameter of the suture, and the 5th whorl 11 mm. in height, and 18 mm. for the suture. The whorls are irregularly convex, slightly constricted in some individuals towards the sutures, which are well defined. The length of the body-whorl is at least double that of the spire, and exceeds it even four times in abbreviated examples. It is much longer than wide—44 to 25 mm. in the figured specimen—the greatest convexity is central and parallel with the suture, and it becomes attenuated towards the base. The test is thin; marked with irregular lines of growth, rarely coarsely ribbed, 3 ribs occupying 2 mm.; or finely striated in the same direction, when there are 5 striæ to a millimètre. Mr. Edwards thus describes the sculpturing: "The edges are slightly pressed against the preceding volution, so as to present a narrow band running round the spire, parallel with the suture; the ribs are rounded, irregular, rather oblique, and slightly thickened above the sutural band, giving a rough crenulated appearance to the edges of the volutions; they are crossed saltier-wise, by very faint obscure lines of growth, perceptible only in well-preserved specimens."[1] The aperture is narrow, longitudinal, elliptical, outer lip crescentic, inner pear-shaped, coming to an acute point above, and more or less rounded below. The lips are thin and sharp. The columella thin, rather bowed and truncated at the base; the latter character affording a basis of separation between this genus and *Achatina*. The length of the shell appears to be 62, and the diameter 25 mm., though these are not the extremes observed in the largest individuals.

The National Collection comprises upwards of 60 specimens, well illustrating the great variability in the relative proportions of the whorls and aperture in this species. The MS. name *brevis* attached to one of the varieties shows that Mr. Edwards contemplated separating it as a distinct species.

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[1] Eocene Mollusca, p. 75.

Most of the specimens are from the Bembridge Limestone, where the shell is rarely preserved, but a few are from the Headon Limestone. It also occurs in the Palæotherium limestone of the department of Aude in the South of France.

It is difficult to avoid uniting this with some of the existing species of *Glandina* from Mexico, so nearly identical are they. Their connection is at all events of the very closest, and as the *Glandinas* are entirely confined to Central America, Mexico, Florida, and the West Indies, the problem as to how they formerly strayed to Europe is interesting. Lying in close proximity on a fragment of limestone in the Edwards' collection are two of these superb snails; one, the *Glandina* (Pl. VI. Fig. 2) and the other, a *Bulimus* (Pl. VI. Fig. 3). They lived together in company, and one may have even succumbed to the carnivorous instincts of the other; but their habitats are now so widely severed that to bring them together again ten thousand miles of sea must be traversed.

The fossil, as already stated, resembles many of the existing species so closely that it would be hard to find any character by which they might be distinguished, especially in the cases of *G. lignaria*, Reeve, of Mexico, and *G. conspena*, Pfr., of Guatemala. It is important to mark that the genus is now entirely confined to the West Indies and the mainland south of Texas, so that its occurrence in the Isle of Wight is alone a hopeless stumbling-block to the acceptance of Mr. Wallace's views.

The animal of *Glandina* is very large in proportion to its shell, into which it retires with difficulty. It crawls with its labial palpæ ceaselessly in movement, and when it comes across a *Bulimus* or a *Helix*, it fastens upon its victim and devours it. The snout is protruded and swells up, and the mouth opens to its largest extent. M. Sallé and Mr. Gould both relate that they have seen the *Glandina* attack individuals of their own species and size. According to Raymond, *G. algira* of Bruguière is exceedingly voracious, and can in 24 hours devour ten or a dozen of *Helix variabilis*. This observer relates that "après avoir flairé sa proie, il penètre assez avant dans le dernier tour de spire des Hélices et fait le vide par succion; on voit trés-distinctement disparaître le mollusque qui lui sert de nourriture."[1]

The Antilles, Central America and Mexico constitute the region in which the genus *Glandina* attains its maximum development. Its carnivorous propensities are abundantly provided for amidst the herbivorous pulmonata which swarm in those regions. The largest species are found in Mexico and Guatemala, where the numerous species of *Bulimus* serve them for food. The eggs are calcareous, as in the large *Bulimi*, and *G. Andebordi* deposits 20, measuring 8 by 6 millims.

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[1] Mission Scientific au Mexique, Recherches Zoologiques, part vii. Etudes sur Moll. Terrestres et fleuves du Mexique et du Guatemala, par P. Fischer, H. Crosse, 1878.

Fam. HELICINÆ.

HELIX (CALOCOCHLEA) GLOBOSA, Sby. Plate VI. Fig. 6.

H. globosus, Sby. 1818, Min. Con. vol. ii. p. 157, t. 170.

The shell is composed of 6 whorls, with an obtuse apex. The whorls rapidly enlarge, each one being more than twice the height of the one above, and the fourth is more than twice the diameter of the third at the suture. The apical angle is very obtuse, but varies considerably within certain limits. The apical whorl seems rounded with the spire flat. The succeeding whorls are slightly rounded or flattened, with the sides at angles of 90° and upwards. In some cases the young are subcarniated, in others not, and the aperture is semilunar or subquadrate according to the angularity of the whorl. The penultimate whorl is much more swollen and the sides steeper and higher in proportion, the height being 26 millim., to a diameter of only 46 millim., the one next above measuring but 8 to 33 millim. The height and diameter of the last whorl are little greater than those of the penultimate, producing the globosely-conical outline which has suggested the name. All the specimens are casts, but in a few cases fragments of the shell remain, which are seen to be very finely striated or more roughly marked with lines of growth. There is the appearance of a small umbilicus as a matter of course in the casts from out of which the columella has been dissolved, but one or two specimens with parts of the shell preserved show it to have been imperforate. The suture is well defined. One perfect cast shows the lip to have been considerably reflected in the adult, and there are indications that it was thickened. The aperture is rounded, the peristome discontinuous, the outer lip forming a semicircle, and the columellar lip and the side of the body-whorl converging to an obtuse point at the columella. The base of the shell is very tumid, and when the shell rests upon it, the axis is inclined at an angle of about 25°. The most perfect specimen measures 45 millimètres in height and 46 in diameter, but the extreme diameter of a less perfect one is 62 millimètres.

Adult shells are very rare and imperfect, and all are from the Bembridge Limestone at Sconce. Young shells are abundant there and also at Bembridge. Though Mr. Edwards has separated some of the casts as *H. occlusa*, and formulates some pronounced characters by which he says they may be distinguished, I cannot follow the grounds of separation in the actual specimens, and it seems to me that it would be advisable to limit the name *H. occlusa* to the Headon Limestone specimens, which are quite certainly distinct.

The shell belongs to the group *Calocochlea*, now limited to, or at least characterizing the Philippines, and might even belong to the living species which most resembles it, *C. Harfordii*. There are many other fine species in the same region, and there is a group, *Camoena*, of shells, in Australia, not disimilar in outline, but umbilicated. Sandberger compares it to one of the latter, *H. Fraseri*, of Cape York.

These, on account of their large size, are the most striking species of the Eocene pulmonate group. Those of less size are as a rule of diminished interest, and most of the true Helices among them at least, present characters recurring in so many widely scattered species, that they are really distinctive of no particular geographical provinces and cannot be definitely assimilated to any one of many existing species which may resemble them. Their detailed description would thus present no new facts of interest in the present research, and they are therefore merely enumerated or their chief characteristics only remarked upon.

HELIX OCCLUSA, Edwards. This comes next in size to *H. globosa*, young shells of which it much resembles. Its widest diameter is nearly 2 centimètres, and its height about 14 mm., the first whorl ⅓ wider than the second. The five whorls are slightly angulated, with polished test and a brown band running round the most salient region, imperforate, and with the lip simple. I regard all the species from the Bembridge Limestone as the immature shells of *H. globosa*, and should limit the species to those from the Headon Limestone. It very strongly resembles *H. incerta*, Fér., of St. Vincent and the West Indies, without however, exhibiting complete identity. *H. Woodwardi* and *H. Etheridgi*, MS. of the Edwards' collection, are probably also young of *H. gobosa*.

H. VECTIENSIS, Edwards, with which should be united *H. cocciphera* and *H. trochila*, MS. species in the same collection, is an almost turbinate and small shell with slightly elevated spire and five rounded whorls, strongly reflected lip, tumid base in which only one whorl is visible, with small umbilicus, finely striate and punctulated polished test. The dots are only faintly visible when magnified 15 diameters, and are not present on the most perfect and figured type specimen even when magnified 40 diameters. The greatest diameter is 1 centimètre, and the height 5 mm. It occurs in the Bembridge and Headon Limestones at Sconce, and nearly resembles *H. fallaciosa* from Ceylon. It is compared to *H. rufescens* by Edwards.

H. D'URBANI, Edwards, is a shell of very similar outline, but is distinguished by its thin and unreflected lip. To this should be added *H. Morrisii*, *H. Keepingi*, *H. omphaloides*, MS. Edwards. It is placed by Sandberger in the sub-genus *Hyalinia*, Agass., of Monfort's genus *Zonites*.

H. SCONCIENSIS, MS. Edwards, possesses the same contour, but has a larger umbilicus, and is somewhat strongly and obliquely ribbed.

H. TROPIFERA, Edwards. A very rare, small shell, from the Bembridge Limestone, with depressed and perfectly angulated spire, tumid beneath, the cast displaying a large umbilicus and semilunar aperture. *H. Coquandiana*, Mathéron, of the Palæotherium Limestone of Aude, in the South of France, seems indentical with it. It is compared by Edwards to *H. lapicida*, recent, of Europe; but it far more resembles *H. tricotropsis*, Pfr., from China, as well in size as contour. The largest of three specimens measures 1 cent. diameter, and 6 mm. in height.

H. OMPHALUS, Edwards, a much smaller shell with 5 very gradually diminishing rounded whorls, very slightly elevated spire, with large umbilicus in the cast, permitting several of the whorls to be seen, and very regularly ribbed obliquely. As pointed out by Mr. Searles Wood, it so closely resembles a group of North American species as to be separable from them only on most trifling grounds. It comes perhaps nearest among them to *H. striatella*, Anthony. Its range seems restricted to the Bembridge Limestone. Sandberger would place it in the genus *Discus*, Fitzinger.

H. LABYRINTHICA, Say.—This minute, but strongly characterized shell from Headon Hill and Hordwell is identified with every propriety with a North American species, ranging from Ohio to Florida and Missouri to Texas. Sandberger, however, considers that there are points of difference, and proposes the name "*pseudolabyrinthicus*," and places it in Anton's subgenus *Strobilus*.

H. SUBLABYRINTHICA, Edwards.—This is a small unique shell of quite different outline to the last, and perhaps more properly referable to *Pupa*. Sandberger mentions an almost identical form as occurring in the limestone of Lautrec.

H. HEADONENSIS, Edwards.—A rare and very minute shell, composed of 6 or 7 rounded whorls, 3 teeth on the outer lip, and wide umbilicus. I have been unable to ascertain that there is any living species resembling it, but Sandberger compares it to *Gastrodonta lasmodon*, Phillips, of Alabama and Tennessee.

The small turrited pulmonates are of greater interest and would well repay a most careful examination. Omitting *Bulimus politus*, which seems to be a freshwater shell, we have the following terrestrial species:

Fam. POMATIASINÆ.

POMATIA[1] HETEROSTOMUS, MS., Edwards sp.—Though described as a *Bulimus*, this clearly belongs to the genus *Pomatia*, a small group of chiefly European species, but with outliers in New Zealand, Rodriguez, Norfolk Island and the Himalayas. It might be identified with one of the European species. *B. Vectiensis*, MS., may indicate a second species, but only casts are known.

Fam. PUPINÆ.

PUPA PERDENTATA, Edwards.—This is a very elongated, cylindrical shell, finely striated and distinguished by the great number of teeth, 14, with which the outer lip is furnished. No living species of *Pupa* seems to come very near to it. Sandberger says that similar though imperfect shells occur in the same horizon in the south of France and at Buxweiler. It belongs to the sub-genus *Torquilla*, Faure-Biguet.

PUPA ORYZA, Edwards.—This a small cylindrical shell, strongly resembling *P. stenopylis*, Benson, and *P. lapidaria*, Hutton, of the Himalayas.

CLAUSILIA STRIATULA, Edwards, *op. cit.*, 1852. Plate VI. Fig. 7.

A very perfect specimen from the Bembridge Limestone has been procured since the species was published, showing it to have been a slender cylindrical shell 24 mm. long, composed of 15 whorls, tapered at both extremities, 4½ mm. wide, sinistral like most of the genus. The entire shell is covered with an exceedingly delicate ribbing, at right angles to the suture and almost parallel to the axis. The ribs are sharp, narrow, and relatively high, and the interspaces are at least three times as wide as the ribs, and five are included in a millimètre. It possesses a projected ovate aperture with slightly reflected lips, which are toothed. There are many living species scattered over the world, but the fossil most closely resembles a group of nearly related species inhabiting the Grecian Archipelago.

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[1] Sub-genus *Pomatia*, Beck.

PUPA MONODONTA, MS., Edwards, from Headon, appears referable to the genus *Megaspira*, possessing the columellar folds or teeth characteristic of that genus.

MEGASPIRA CYLINDRICA, MS. Edwards.—The unique specimen known is from the London Clay of Finchley, and is a small turrited finely striated shell with peculiar transversely plaited columella, appearing identical with *M. exigua* from Ports Molle and Curtis.

Fam. SUCCININÆ.

SUCCINEA IMPERSPICUA, S. Wood, is a true *Succinea*, very probably belonging to a still existing species, but the living forms are so indistinguishable from each other, and the genus is so widely distributed, that an exact identification would be difficult, if not impossible. The fossils are from Headon and Hordwell.

Fam. OLEACINIDÆ.

ZUA.—Two small species, *Z. Headonensis* and *Z. dubia*, Edw. MS., smooth cylindrical shells, are referred to the very limited recent genus *Zua*, but the propriety of this determination appears doubtful.

All the preceding species require further correlation with those already described from Tertiary beds of other parts of the world, more particularly with those of the Eocene Paris Basin, as it seems hardly possible, in view of the number of plants common to English and European Eocenes, that so many should be peculiar to so limited an area. There is no doubt but that an exhaustive comparison would enable many more of the fossil species to be identified with living. Very few, I believe, would be found wholly extinct, for the persistence of specific types of land snails through long geological ages is one of the noteworthy facts in the history of Mollusca. Many of the genera are known to have existed indeed in the Carboniferous. The facts already brought to light demand a very complicated redistribution of land and water, and are certainly incompatible with Mr. Wallace's views of the permanence of continents through all geological time. I prefer for the present however to withhold those more definite conclusions which the material, even so far as already examined, would justify me in putting forward.

EXPLANATION OF PLATE VI.

Land Mollusca from the Upper Eocene, Bembridge Limestone, Sconce, I. of Wight.

FIG. 1. *Bulimus* (*Amphidromus*) *lævolongus*, Boubée, 1844.
,, 2. *Glandina costellata*, Sowerby, sp.
,, 3. *Bulimus* (*Amphidromus*) *ellipticus* (young), Sby. sp.
,, 4. ,, (,,) ,, (adult).
,, 5*a*. Egg of *B. ellipticus* (?). 5*b*. Section through same.
,, 6. *Helix* (*Calocochlea*) *globosa*, Sby.
,, 7. *Clausilia striatula*, Edwards.

All drawn natural size.

II.—CONTRIBUTIONS TO THE PALÆONTOLOGY OF THE YORKSHIRE OOLITES.

By WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S.

(Concluded from p. 207.)

Genus ACTÆON, Montfort=*Tornatella*, Lamarck.

Two species, or at least two well-marked varieties of one species, occur in the lower beds of the Inferior Oolite of Yorkshire, which cannot be referred to *Actæonina*, but which are provisionally placed under *Actæon*. The type is the well-known *Auricula Sedgvici*, Phil., characteristic of the Dogger, though far from common, and almost impossible to obtain in a perfectly satisfactory state. Hence the chief difficulty.

These shells are ovate, with a shortish spire, the last whorl ventricose, surface spirally striated (more deeply than in any species of *Actæonina*), columella thickened, and somewhat oblique, but not plicated, if I have correctly interpreted the available specimens. The aperture is relatively shorter than in *Actæonina*, and, owing to the effuseness of the outer lip, almost semilunar in outline. The general aspect of these shells is greatly that of *Actæon*; but, as far as my experience goes, they are without the fold.[1]

92.—ACTÆON SEDGVICI, Phillips, 1829. Pl. V. Fig. 4.[2]

1829-1835. *Auricula Sedgvici*, Phillips, G. Y., p. 129, pl. xi. fig. 33.
1849. *Actæon Sedgwici*, D'Orb (Phil.), Prod. i. p. 263. Et. Baj.
1850. *Actæon Sedgvici*, Phil.; Morr. and Lyc. Gt. Ool. Moll. p. 118, pl. 15, fig. 9.
1854. *Actæon Sedgwickii*, Phil.; Morris, Cat., p. 233.
1875. *Actæon Sedgwickii*, Phillips, G. Y., 3rd edition, p. 260, pl. xi. fig. 33.

Compare also,

1837. *Tornatella pulla*, Koch and Dunker, Verstein. pp. 33, pl. 2, fig. 11.
1848. *Tornatella pulchella*, Deslongchamps, Mém. Soc. Linn. Norm. viii. p. 162, pl. 18, fig. 4.
1850. *Actæon pullus*, Morris and Lycett, Gt. Ool. Moll. p. 119, pl. 15, fig. 11.
1852. *Actæonina pulchella*, D'Orb (Desl.), Terr. Jur. ii. p. 169. pl. 268, figs. 7, 8.
1876. *Actæonina pulla*, K. and D., Tate and Blake (Yorkshire Lias), p. 356.

Bibliography, etc.—The references, given for comparison as above, may in some cases be more applicable to the *Actæon pullus* of Morris and Lycett, presently to be described as a variety, which occurs in the Millepore Rock of the coast. All the specimens seen by me from the Dogger more resemble Phillips' type, whether they are small or great; consequently I should be led to suspect that this is the form noted by Tate and Blake in the Upper Lias, where a single specimen was found. In the few cases where the aperture has been visible it is invariably without plication. Should a specimen exhibiting such strong plication as is depicted by Deslongchamps in his *Tornatella pulchella* ever be found, the case would be different. It

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[1] Stolizcka notices this group of shells (*op. cit.* p. 404), and is disposed to place them under *Bullinula*, Beck (*Bullina*, Fér. apud H. and A. Adams). He observes that the two oldest species apparently belonging to this genus are the Jurassic *Actæonina pulchella*, D'Orb., and *Act. striato-sulcata*, Zittel and Goubert. Subsequently he refers, though with more doubt, to the Yorkshire fossils now under consideration.

[2] For Plate V., see the May Number of the GEOL. MAG.

24	—— *gemmatum*, M. & L.	...	...	...	...	...	...	•	*	c.
25	—— *Beanii*, M. & L.	...	...	...	*	...	...	...	...	...
26	—— *Leckenbyi*, sp. nov.	r.	c.	...	vr.	...	...	...	...	...
27	—— *turris*, sp. nov.	...	vr.	...	...	...	...	...	...	...
28	—— *Comptonense*, sp. nov.	...	vr.	...	...	...	...	...	...	...
[illegible]	[illegible]	...	...	vr.	...	...	...	...	...	...
•	"*Trochus*" *jugosus*, Bean, MS.	... ...	... vr.	... ...	... ...	* ...	... ...	... ...	... ...	... ...

To illustrate Mr. W. H. Hudleston's paper on the Palaeontology of the Yorkshire Oolites. Geol. Mag. June, 1885, to face p. 256.

should be mentioned here that Brauns considers *Tornatella pulla*, K. and D., the same as *Actæon pullus*, M. and L., but different to *Auricula Sedgvici*, Phil. (see his table of synonyms, Mittl. Jura, p. 194.)

Description.—Specimen from the Dogger (zone 1), Peak (Blue Wyke). Bean Collection, British Museum. About 10 mm. in height and considerably more than half as wide as high.

Shell ovate, with a short spire composed of about 3 whorls, apex somewhat obtuse. The whorls are exceedingly tabulate, with a well-marked suture. N.B.—The stumpy character and tabulate whorls of *Actæon Sedgvici* are better shown in the figures of Phillips, and of Morris and Lycett, than in the accompanying Plate. Body-whorl large in proportion to the rest of the shell, and barrel-shaped.

The body-whorl and penult are ornamented by fine spiral grooves, which are but slightly punctate: the surface of the body-whorl is thus divided into a number of strap-like belts, of which two, situate slightly below the middle, are wider than the rest, and constitute a somewhat conspicuous feature. Other indications wanting.

N.B.—The average of specimens appear to be considerably smaller than the one figured.

Another specimen.—Same horizon and locality. York Museum. Possibly the type. Not figured.

The stumpy character of the spire, and barrel-shaped outline of the body-whorl, are well shown in this specimen, which, though small, is in good preservation and free from matrix—a very rare circumstance. The aperture is wide and semilunar, the outer lip being somewhat effuse: columellar region much excavated; columella thick, prominent, and oblique, but not plicated.

Relations and Distribution.—It is evident that fossils very nearly approaching this species occur on a low horizon in the Inferior Oolite elsewhere. In Yorkshire one example has been met with, as we have seen, in the Upper Lias of the Peak; otherwise, it occurs only in the Dogger. I have seen it from the "Green Bed" of Casterton near Stamford along with the characteristic *Astarte elegans*. This is, I presume, on the horizon of the Northampton Sand. It must, however, be rare in other parts of England, nor have I yet seen it from the rich shell-beds of the south-west. The figures of D'Orbigny and of Koch and Dunker lead me to suppose that the fossils referred to by those authors are much more closely related to *Actæon Sedgvici*, than to the variety described by Morris and Lycett. Hence I have very little doubt they are something more than merely representative species. D'Orbigny seems to have doubted the three folds in Deslongchamps' specimen from Les Montiers. Until this point is cleared up, it would be useless to institute any further comparison. Nothing of the sort is shown in D'Orbigny's figure.

Description of variety *pullus*, M. and L., Fig. 5.—Specimen from the Millepore Rock (zone 2), Cloughton. Bean Collection, British Museum. ? Type.

Height about 7 mm., and extreme width about half the height.

Shell ovate, subelongate, with a spire composed of about four whorls, which are slightly tabulate and moderately tumid. Body-whorls relatively large, and somewhat barrel-shaped. The body-whorl, and probably the penult, are ornamented by fine spiral striæ, but the condition of the fossil, in this peculiar matrix, is not favourable to close discrimination.

The length of the aperture is slightly less than half the height of the shell, the outline being elliptical; the columella is excavated and encrusted, but not plicated, outer lip curved.

This variety, *pullus*, has a smaller spiral angle, and a better developed spire than *Actæon Sedgvici.* It is probably the form more likely to be found in higher horizons. There are two specimens in the Leckenby Collection marked "*Tornatella*, Millepore Bed, Scarborough," which probably belong to *Actæon pullus*. In the same Collection there is likewise a fossil marked "*Actæon*, Cornbrash, Scarborough." which cannot be very far removed from this form, but its condition is such that accurate identification is impossible.

Genus BULLA, Klein, 1753.

93.—BULLA UNDULATA, Bean, 1839. Plate V. Figs. 10, 10*a*.

1839. *Bulla undulata*, Bean, Mag Nat. Hist. p. 61, fig. 22.
1850. *Bulla undulata*, Bean, Morr. and Lyc., Gt. Ool. Moll. p. 96, pl. 8, fig. 8.
1875. *Cylindrites* (*Bulla*) *undulata*, Bean, Phillips, G.Y., 3rd edition, p. 260.

Bibliography, etc.—This was one of the discoveries of Bean subsequent to the publication of the earlier editions of the Geology of Yorkshire. Phillips in his last edition refers the Cornbrash shell to *Cylindrites*, which genus he evidently regarded as more nearly related to *Bulla* than to *Actæon*, notwithstanding the plication of the columella.

Description.—Specimen from the Cornbrash (zone 4), Scarborough. Leckenby Collection.

Height	31 millimètres.
Width in proportion to total height	77 : 100.

Shell oval, ventricose; marked by broad and irregular lines of growth. Apex perforated; aperture longer than the body of the shell, rounded at each end, relatively narrow behind, but rounded and excavated in front: outer lip slightly arcuated.

N.B.—This specimen has been rather compressed.

Relations and Distribution.—This is a truly common type, the Scarborough fossil only differing from the existing *Bulla ampulla* in being slightly shorter, and in the apparently more rugose habit of growth: but this latter feature is of little value when we compare shells with fossils. It also varies much in size like *Bulla ampulla*, some of the Scarborough specimens being much larger than the one figured; whilst, on the other hand, specimens from the Great Oolite of Minchinhampton, where it is rare, are said to be smaller, and to have the inner lip more sinuated.

Bulla suprajurensis, Rœm. (Ool. Geb. p. 137, pl. 9, fig. 33) is a small representative of this group in the Upper Jura, and since an almost identical form is now living, its occurrence in other strata may naturally be expected.

In Yorkshire *Bulla undulata* is only from the Cornbrash: it differs very considerably from the fine species of *Bulla* which occurs in the Coral Rag of Ayton (see "Corallian Gasteropoda," GEOL. MAG. 1881, Pl. IV. Fig. 6).

APPENDIX AND EXPLANATION OF TABLE.

Note as to "*Trochus*" *jugosus*, Bean MS.—Pl. V. Figs. 11, 11*a*. Shell conical, turrited; whorls 5 or 6: suture well marked, and situated in a hollow. The whorls of the spire are angular, and slope outwards to a very prominent carina situate about two-thirds down. Keels sharp and apparently plain. Faint traces of a lower keel may be noted in the whorls of the spire: body-whorl strongly bicarinate. The whole of the shell, including the base, is marked by fine spiral lines. Aperture involved.

I can hardly believe that this is a *Trochus*. It has more the look of an *Alaria* without the wing. On the other hand, it may represent a shell which never had a wing. I would here direct attention to the peculiar fossil called by Deslongchamps *Turritella unicarinata* (Mém. Soc. Linn. Norm. vii. p. 151, pl. xi., fig. 68) said to come from the Oxford Clay of Dives. The author admits its resemblance to "*Rostellaria*," but has no doubt that it should be referred to *Turritella*.

"*Trochus*" *jugosus* in Yorkshire is confined to the Dogger, where it is very rare.

Note as to *Nerinæa*.—I have to thank Mr. Witchell of Stroud, and Mr. Walford of Banbury, for drawing my attention to some points in connection with this genus, by way of supplement to the remarks made by me in the GEOL. MAG. 1884, p. 108, *et seq.*

Mr. Witchell writes, "I have never seen *N. cingenda* in the Pea Grit, but doubtless Dr. Wright must be correct in putting it in his list. One of the characteristic shells of the Pea Grit in the Stroud area is *N. oppelensis*, but Dr. Wright has mentioned it as occurring in the Oolite Marl at Selsey Hill. This is an error. For 'Oolite Marl' read 'Pea Grit.' Your shell, Plate IV. Fig. 8, is, I think, the same species. I have also a *Nerinæa* from Bradford Abbas, and Mr. S. S. Buckman has several examples . . . . I have not found the genus in any bed lower than the Pea Grit, although I have seen in the *cynocephala*-zone a spiral shell which may possibly be a *Nerinæa*."

Mr. Walford reminds me that the late Mr. Charles Moore described *Nerinæa liassica*, in his Middle and Upper Lias of the S.W. of England. It does not yet seem absolutely certain what this shell really is. I have never seen a specimen myself. Mr. Walford possesses one about 4 mm. in height.

I may also mention in reference to this subject that none of the so-called *Nerinææ*, which have been described from the Trias of the Continent, are like typical *Nerinææ* in respect to the columella and disposition of the folds, though such shells may possibly lead up to the more typical forms of the genus.

Note on *Nerita costulata*, Deshayes. — Mr. Walford writes: "In your comments in the Geol. Mag. on *N. costulata*, you speak of it as not occurring in the G. O. I have several specimens from the base of that formation with the slight mesial angularity and thickening of the costæ you quote. One form approaches *Nerita rugosa*."

Note on "*Phasianella*" *latiuscula*, Morris and Lycett.—No shell of this "species" has yet been seen by me; but bearing in mind the very considerable abundance of the so-called "*Phasianellæ*" allied to *P. elegans* in the Lincolnshire Limestone, I have less hesitation in admitting this "species" into the Table of species retained.

Note as to *Cerithium Comptonense.*—Owing to some mistake, this species is described as occurring at Compton. It really occurs at Weldon. The name, however, having been given, should stand.

Note on *Trochotoma calix.*—It appears that the specimen figured (Plate IV. Fig. 6) in the April number of the Magazine is regarded at York as the type of *Solarium calix*, Phil. Therefore the first half of line 1, p. 157, should be cancelled.

Note on the Table of Fossils.—The accompanying Table in a great measure explains itself. The numbers in the left-hand column refer to the enumeration in the text, and each number usually represents what is deemed a species. The right-hand columns, seven in number, indicate the fossiliferous zones, and the star or letters the occurrence of the species. A few are noted as ascending into the Corallian. The number of representative forms in the Corallian is much greater.

I have often expressed the opinion that we must not rely too much on Tables. They are apt to accentuate the palæontological breaks in a given series of beds, and at best are only a somewhat unsatisfactory contrivance for affording a synoptical view. At the same time, such a Table as this may be relied upon to indicate how the Gasteropod fauna of the Yorkshire Oolites continued to diminish in richness from the fine start it made in the Dogger, until it became very poor indeed in the beds immediately underlying the Coralline. Two species already enumerated in the "Corallian Gasteropoda" should, however, be added to those of column vii, which represents the Lower Calcareous Grit. These are (1) *Littorina muricata*, Sow., var. A, which takes the place of *Turbo Phillipsi*, M. and L.; and (2) *Actæon retusus*, Phil.

Taking a comprehensive view of the case, and not relying too much on the Table, the results are that a somewhat scanty series of Gasteropoda in the Dogger Sands is succeeded by a really rich Gasteropod fauna in the Dogger. Most of the genera known to occur in the Yorkshire Oolites are well represented on this horizon. The genera conspicuous for their absence or rarity are the so-called "Phasianellas" of the *P. elegans* type (*Pseudomelania*), *Trochus*, and *Pleurotomaria*. On the other hand, *Purpurina*, *Nerinæa*, *Alaria*, *Onustus*, *Neritopsis*, and *Trochotoma* now appear for the first time in the Yorkshire Jurassics. In the case of *Nerinæa* and *Alaria* these are well represented both in individuals and probably in species: certainly they are in varieties; but the conditions of preservation require some latitude in the determination of these points. Certain demoid types are, it seems to me, the same in the Dogger and in the Corallian Rocks, such as *Cerithium muricatum*, and probably species of *Littorina* and *Delphinula*, which are certainly difficult to distinguish from well-known Corallian forms. On the other hand, the abundant *Chemnitzia lineata-procera* of the Dogger has its representative species on the higher horizon in *Chemnitzia Heddingtonensis*. And so it is with most of the Corallian species: they are representative rather than identical, yet in many cases possessed of a strong family likeness to their predecessors of the Dogger. The following Corallian genera have not yet been enumerated in the Dogger, viz. *Purpuroidea*, *Pseudomelania*, and *Cylindrites*.

For purposes of comparison we must treat the Millepore Rock and Scarborough Limestone as one zone, owing to the difficulty of separating the specimens in those cases where the nature of the matrix cannot always be relied upon to assist in the discrimination. Together they contain about half as many species as are yielded by the Dogger: the most abundant forms are decidedly those of the Dogger fauna, especially in the Millepore Rock, as might be expected. About one-third of the species in the Scarborough Limestone, or third zone, passes up into the Cornbrash. where, however, the prevailing species are very different. Somewhat less than a third of the Cornbrash species passes up into the Kelloway Rock. Hence the Cornbrash occupies a somewhat isolated position as regards its Gasteropoda. The few species which occur in the "Oxford Clay" are, with one remarkable exception, forms which have been noted in the Kelloway Rock, and almost the same may be said of the few species known from the Lower Calcareous Grit—at least these latter are, for the most part, no more than varieties.

As before observed, the Gasteropod fauna of the Yorkshire Oolites had now sunk to an extremely low ebb, previous to that wonderful revival of which the Corallian Rocks have afforded such excellent proofs.

End of Memoir No. 2.

ERRATA.

Memoir No. 1.

Geol. Mag. 1881.

p. 122, line 11, for 'had' read 'have.'
p. 127, line 4, for '1870' read '1810.'
p. 127, below line 16, insert *Actæon retusus*, Phillips, G. Y. pl. iv.

Memoir No. 2.

Geol. Mag. 1882.

p. 193, line 18, for *Pictte* read *Pietti*.
p. *ib.* line 20. for 'Superior' read 'Inferior.'
p. 250, line 17, for 'Montl.' read 'Montr.'

Geol. Mag. 1884.

p. 200, line 11, for *Cerithiæ* read *Cerithia*.
p. 245, line 3 from bottom, for *armata* read *armigera*.
p. 201, line 4 from bottom, *dele* ,.
,, line 5 from bottom, for *turrited* read *twisted*.

III.—A PLEA FOR COMPARATIVE LITHOLOGY.

By C. CALLAWAY, D.Sc., F.G.S.

IN a short series of papers in this MAGAZINE[1] on *How to work in the Archæan Rocks,* I briefly set forth the principles of correlation which seemed to me available, and pointed out the precautions which should attend the application of each test. I discussed the evidence from (1) *Organic remains*; (2) *Order of superposition*; (3) *Included fragments*; and (4) *Mineral composition.* The last-named criterion has the widest application, and therefore it was necessary to define its scope with great care. I showed that its value largely depended upon accessory considerations. I insisted that rock-groups should be compared *as a whole,* that the *degree of metamorphism* was an important factor in the evidence, that a valuable auxiliary test was to be found in *similarity of succession,* that the proof of a *Pre-Cambrian age* enormously reduced the chances of error, and that, in some cases, the *origin of the deposits* was a useful aid in correlation. I recall attention to these points, because, at a recent debate[2] in the Geological Society, some of my critics seemed to believe that I had been attempting to determine the age of formations by the comparison of a few hand-specimens. They omitted to take fully into account the subsidiary evidence which has been accumulated during the last decade. But even if we entirely ignore this mass of proof, it is surely of interest to point out lithological resemblances between rock-systems, even if we are not prepared to correlate them. Twilight is better than absolute darkness. We may say that the Pebidian of Hicks is like the Lower Taconic of Emmons, without asserting the contemporaneity of the two groups; and then leave the lithological hint at the mercy of the evolutionary laws which will either destroy it or develop it into a theory.

In the debate to which I have referred, it was suggested that as attempts to correlate ordinary sediments by means of mineral characters had broken down, and similar efforts in connection with igneous rocks were sharing the same fate, it was useless to apply the lithological test to the crystalline schists. This argument is not without apparent force, and requires careful analysis.

It is quite true that amongst Post-Archæan strata we do not pay much attention to mineral composition; but the reason for our comparative neglect is not that we love lithology less but fossils more. If, however, organic remains were to vanish out of the earth's crust, the geological record would not become an utter blank. We should venture to identify the Chalk on both sides of the Straits of Dover, without thinking it necessary to run a tunnel to prove absolute continuity; and if some bold lithologist were to refer Caen stone to the age of our Oolite, we should not brand him as a mere dreamer. But each case would be determined on its own merits, and it would be impossible to establish even an empirical law of correlation.

The objection of my critics proceeds upon the assumption that there is the same absence of law amongst the Archæan rocks. It was difficult to meet this attack when it was currently believed that crystalline schists might be of any age. But year after year this belief grew weaker, as mass after mass of so-called Cambrian or Silurian strata fell back into the Archæan; until at last those who had made a special study of the old rocks thought they could detect amidst their complexities the dim outline of a law. The existence of this principle, if it can be established, will raise comparative lithology into a valuable test of the age of a rock-system. I will not venture to definitely formulate this suggestion; but I will go so far as to say that our present knowledge lends some support to the conclusions that, in the British area at least, crystalline schists have not been manufactured on a large scale in Post-Archæan times, and that, amongst the Archæan rocks, the antiquity of a schist is in direct ratio to its degree of crystallization. I do not say "degree of alteration," because this would involve a theory, and introduce complication.

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[1] Aug and Sept., 1881.

[2] On my Donegal paper, March 11th, see abstract, printed on p. 278.

I have not forgotten Prof. Lapworth's ingenious application of the mechanico-chemical hypothesis of metamorphism to certain of the Highland schists. But as he has, with rare magnanimity, abandoned the publication of the evidence to the hands of the Geological Survey, we must postpone discussion of the question till the official memoirs are issued. Whatever the result, the main conclusions of Archæan geologists will not be materially affected. Even if all the newer Highland schists were thrust back into the Silurian system, the Archæan age of the schists of England and Wales would not be touched. Each case has been established by independent evidence, and can be overthrown only by the refutation of that proof. But should my Caledonian system be destroyed by the new theory, some modification of the suggested law would of course be necessary. It would still be applicable within certain limits and under certain conditions. Indeed, I do not even now claim for it any more than an empirical and local value.

I start with the proposition that in Britain there occur (at least) two Archæan groups, of which the older is coarsely crystalline, and the younger either eruptive or hypocrystalline. These are the Hebridean and the Pebidian. There is some reason for believing in the existence of a third series, intermediate in age and degree of crystallization between the two; but to limit controversy I exclude this group. The Hebridean and the Pebidian are as truly rock-systems as the Cambrian and the Silurian. I will briefly review the evidence.

At St. Davids, we have a granitoid mass (Dimetian) overlain by a newer group, partly volcanic, partly hypocrystallnie, constituting the typical Pebidian of Hicks. The Archæan age of the Dimetian has been recently attacked, so that I will not insist upon it here; but it is admitted on all hands that the Pebidian underlies rocks containing the most ancient Cambrian fossils known; so that even if there were no break at the base of the fossiliferous beds, we must grant that the Pebidian is more ancient than anything which can be proved to be Cambrian.

I feel myself on firmer ground in Shropshire. The gneiss of which Primrose Hill is a fragment is highly crystalline. It is older by an interval than the Wrekin volcanic series (Uriconian), for it has furnished pebbles to Uriconian conglomerates. The Wrekin group is either volcanic or hypocrystalline, and it is certainly older than the Longmynd series, for the purple conglomerates and sandstones of the latter are largely derived from it. There is a third Archæan group in Shropshire, the quartz-schists of Rushton, but these I leave on one side. The existence of at least two Archæan systems in the Wrekin area I hold to be absolutely certain.

In Caernarvonshire also there are two groups, a granitoid mass like the Dimetian, and a volcanic series similar to the Uriconian. Both of these are Archæan, since Harlech conglomerates contain pebbles derived from them.

Anglesey likewise affords proof of two ancient systems. The older is gneissic and granitoid. It furnishes rounded fragments both to a hypocrystalline series and to the lowest Palæozoic rocks in the island. The hypocrystalline group supplies pebbles and large angular pieces to conglomerates which are of at least Arenig age, and may be older.

These facts receive confirmation from other areas where the evidence is less satisfactory. The Malvern chain, consisting of highly crystalline gneiss, is flanked on the east side by altered rocks which closely resemble Pebidian types at St. Davids and in Shropshire. In the Midlands, near Nuneaton, volcanic rocks of the Charnwood series are said to underlie quartzites which are certainly not younger than the Cambrian.

The conclusions thus briefly stated represent the independent observations of several well-known geologists, each differing from the rest in some points, as might be expected from the difficulty of the work, yet agreeing with them in the main facts. As I have worked out some of these results, and personally verified nearly all the rest, I can speak with some confidence, and I do not hesitate to say that the existence in England and Wales of two well-marked groups older than the Cambrian has been clearly proved. The younger of these systems is usually volcanic; but the centres of activity are, as we should expect from analogy, sporadic. In the Wrekin, massive lava-flows alternate with ash-beds, breccias, and bands of hornstone; but a few miles to the north-east, in Lilleshall Hill, rhyolites are apparently absent, the ridge consisting of well-bedded ashes, hornstones, and altered shales, together with some masses of volcanic breccia. These strata are precisely such as would be formed by volcanic action at a distance from the centre of eruption. The altered shales and hornstones form a connecting link between the typical volcanic products and the hypometamorphic schists of some other districts.

In North Wales, the phenomena are similar; but we can go a step further. The rhyolites of Llyn Padarn and south of Bangor are obviously not far from volcanic foci. They are overlain near Bangor by conglomerates and grits, both of which are largely derived from rhyolitic material. At the city of Bangor, a little further from the lava-masses, we come to agglomerates and altered slates, the latter made up of "volcanic dust." In Anglesey, we are at a still greater distance from the centre of eruption. Lavas are seemingly wanting, but almost every other Pebidian type known to me in South Wales and Shropshire occurs. The most abundant varieties are felspathic breccias, hornstones, and fine-grained altered shales. These rocks are older by an interval than (at least) the Arenig period, and they are utterly unlike any part of the Cambrian group, so that their Pre-Cambrian age is almost certain, even if we disregard their close resemblance to the Pebidian. Associated with these Pebidian types, in such a way as to prove that they are parts of the same system, we find pale-green slates, like those of Charnwood, grits, conglomerates, quartzites, dolomites, and chloritic schists. The grits and the matrix of the conglomerates often display alteration, the slates are frequently hypocrystalline, and the schists are sometimes almost as highly crystalline as those of Holyhead. This region has been affected by powerful lateral pressure, giving rise to complex contortion and thrust-planes; but whether or not the earth-thrust has produced the metamorphism does not concern my present inquiry. I will merely observe that the crystallization existed in Pre-Cambrian times; and that the Ordovician rocks have been intensely crumpled and repeatedly sliced by thrust-planes, yet they have undergone no metamorphism beyond the cleavage stage.

Our studies seem then to prove that in South Britain crystalline schists in regional masses occur only in Archæan groups, and that of the two well-established systems, the younger exhibits but partial crystallization. These facts appear to shape themselves into a law, empirical at present, but of sufficient authority to raise a strong presumption in favour of its application to a wider area.

If then we cross St. George's Channel, and find a Pre-Cambrian series with mineral and petrological characters similar to the Pebidian, displaying also a hypocrystalline structure, varying in like manner between slight alteration and fairly distinct schistosity, are we rash in assigning such a group to the Pebidian system? If this inference be resisted, if belief is refused until we can trace Pebidian rocks under the sea from Anglesey to Ireland inch by inch, I dare to think that such scepticism is irrational and destructive of scientific progress.

I have already, in this MAGAZINE, November, 1881, p. 494, given reasons for believing that in the south-east of Ireland there are two Archæan groups, probably corresponding to the crystalline and hypocrystalline formations of Anglesey. An important fact, which I wish to recall, is that, in the region south of Wexford, the direct proof of Archæan age is very strong. The masses of gneissic and hypocrystalline rock lie side by side with areas of Cambrian and Ordovician strata; yet I could nowhere find evidence of a passage between any two of the groups. The Palæozoic slates and shales displayed no alteration, but abutted against the schistose rocks with sharp lines of junction.

I regard Anglesey as the stepping-stone between the typical Pebidians of South Britain and the hypocrystalline rocks of Leinster. A sketch of a few Leinster sections will here be given.

The Hill of Howth.—The rocks of this well-known promontory, projecting into the Irish Sea north of Dublin Bay, have been referred by Irish geologists to the Cambrian epoch. The lithology of the strata, however, does not lend any support to this view. Taking the section from north to south, we have the following succession:—

1. Light-grey altered shales.
2. Similar shales, interstratified with quartzite.
3. *Ibid.* with pale-green schistose slate and purplish-grey shales.
4. Pale-green breccia, fragments of green schistose slate like the first variety in 5, matrix gritty, with schistose lustre.
5. Pale-green and yellowish altered shales, described by Prof. Bonney[1] as "rather talcose or serpentinous"; interbedded with quartzite and overlain by a great mass of the same.
6. Quartzose grit interstratified with and overlain by pale-green shales.

The resemblance of these strata to the hypometamorphic (Pebidian) series of Anglesey is very marked. Quartzites are not known in the Pebidian of South Wales; but they occur in that group in Anglesey. In Howth Hill they are still more conspicuous. On the other hand, there is little likeness between the Howth rocks and the purple and green aluminous slates and unaltered grits of Bray Head and the Devil's Glen, which are usually placed in the Cambrian.

Carrick Mountain (Co. Wicklow).—This ridge is made up of quartzite interbedded with yellowish, greenish, and purple mudstone or shale with a north-westerly dip. These rocks are not unlike some of the less altered varieties of the Pebidian, but I hesitate to speak positively.

Aughrim (Co. Wicklow).—I made the following notes of this locality:—

1. One mile N.N.E. of the town. Grey schistose shale; dip S.S.E. at 65°.
2. One-eighth mile north of Macreddin Bridge and ridge east of the same. Altered slaty beds; black subcrystalline schist; same dip.
3. Quarter-mile S.S.E. of Three Wells. Similar altered slates; same dip.

The rocks of this district have a marked Pebidian facies.

Wexford District.—Two bands of newer Archæan and Lower Palæozoic rock, striking W.S.W., are separated by a strip of Carboniferous Limestone.

The *Northern Zone* is largely composed of quartzite and other altered rocks. Going in a north-westerly direction from Wexford town, we pass over the following section:—

1. Quartzite interbedded with black schists.
2. Green shale or slate, much mineralized.
3. At Carrick Bride, we have altered green slates. These appear

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[1] In MS. notes kindly furnished by my desire.

in the microscope to Prof. Bonney as "schist of late type or perhaps only schistose . . . . fragmental structure still conspicuous."

4. Similar schistose rocks, more highly mineralized.

5. Quartzite (South of Carrick Bridge), with thin seams of soft grey or whitish schist.

The dips of the above are at 40°—65° to N.N.W.

At Bannow Bay, we are towards the western end of the same band. East of the Bay, the rocks are grey shales (Ordovician) and light-green and purple clay-slates (Cambrian); but east of Ballymadder Point, Pebidian rocks are well exposed. Grey and greenish schistose slates of the type prevailing N.W. of Wexford occur. A variegated green and white variety is beautifully contorted. We have also some hornstone-like slates and laminated hornstone.

The Pebidian rocks of the Southern Zone are well seen in a traverse from Ballycogly to Tom Haggard. The rocks are tolerably uniform from end to end, consisting typically of pale-green altered slates, with some gritty bands. The mineralization is not so great as in the Northern Zone. The strike is to the W.S.W., and the dips northerly at 50°—85°. I saw no quartzites here.

North-west of Greenore Point, there is an outcrop of the ordinary altered slates or shales, and a band of fine-grained crystalline limestone. At the Point is a rock which Prof. Bonney thinks is "probably an andesitic lava."

In the Hill of Howth and near Aughrim the evidence for a Pebidian age is, so far as I know, purely lithological. In these localities, it may be objected that I am the victim of hand-specimens. But if the rocks are not Pebidian, what are they? No one has proved that they contain Cambrian or Silurian fossils; and they do not form part of any known Palæozoic formation. We are thus driven back upon comparative lithology. If we reject this test, we are left in utter darkness. In Anglesey and south of Wexford, we fortunately possess stratigraphical evidence of Pre-Cambrian age, which in northern Leinster appears to be wanting; but since the rocks of Howth and Aughrim are quite unlike anything we know of Cambrian or Silurian age, while they display a marked resemblance to the Anglesey and Wexford Pebidian, both in mineral characters and state of crystallization, I hold that I am fairly justified in referring them to the Pebidian system. At the very least, I have a right to challenge those who call them altered Cambrian or Silurian to offer evidence for their contention.

When we pass to Ulster, we find a group of strata which I have called the *Lough Foyle Series.*[1] The lithological resemblance between these rocks and the Pebidians of Leinster and Anglesey is very marked. Quartzites, quartzose grits, foliated grit, schistose shales and slates, schists with distinct clastic structure, and black phyllites or subcrystalline schists, are the chief types. This is not a case of similarity between two *kinds* of rocks, but between two *assemblages* of rocks. We have in Ulster a group mainly composed of six or eight varieties, and in Leinster is found a group chiefly made up of six or eight similar varieties. In both groups the degree of crystallization varies between the slightly altered and the minutely crystalline; but in Ulster the general aspect of the series is rather more schistose. If the L. Foyle Series is not Pebidian, what is it? Fossiliferous Caradoc strata occur on the margin of the Ulster schistose area, but the former are mere shale and sandstone, as unaltered as any English Ordovician rocks, and displaying no signs of transition towards the hypocrystalline state. If the L. Foyle Series is claimed as Palæozoic, I have a right to demand proof of the assertion. I should also like to inquire why a metamorphosed Palæozoic group should present an assemblage of rocks resembling so closely the Pebidians of Leinster and Anglesey.

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[1] Quart. Journ. Geol. Soc. May, 1885, p. 22.

The conclusions which I have been advocating are strongly supported by a comparison with some distant areas. Of these, space will not permit me to give more than one example, which I select for the clearness of the evidence. Mr. J. E. Marr, in his paper "On the Pre-Devonian Rocks of Bohemia,"[1] states that beneath the Lower Cambrian strata he found two well-marked groups. The older was gneissic. It furnished pebbles to the younger, which is described as having been "subjected to but slight metamorphism, and that only in places," and consisting of "green schists, grits, ashes, and breccias, interstratified with variously coloured hornstones." These rocks in their turn supply rounded fragments to the Lower Cambrian. Mr. Marr refers the younger Pre-Cambrian series to the Pebidian, the older to the Dimetian. This interesting case shows us that in Pre-Cambrian times similar conditions extended over wide areas, and confirms our faith in the utility of comparative lithology, when applied with due precautions.

I have thus given in outline the reasons why, amongst the Archæan rocks, lithological evidence possesses a value *sui generis.* I hold that the principles which regulate its application to ordinary sedimentary strata and to igneous rocks do not apply to the crystalline schists. That Pre-Cambrian rocks should have been exposed to conditions, mechanical, thermal, and chemical, which did not extend, or extended but partially, into Palæozoic times, is only what we should expect. What those conditions were is one of the most important problems presented by our science; yet I cannot but think that the question will hardly be ripe for settlement till we have ascertained with certainty the true Archæan succession. In America, some fundamental points, such as the relation of the Huronian to the Montalban, are in hot dispute; and though the light seems a little clearer in our own area, we can do little more than see men as trees walking. Some amongst us regard our Archæan studies as barren and unpromising. It seems to me, on the other hand, that our investigation is opening out most fruitful fields of labour. We are working at the great question of the origin of the crystalline schists, and striving to throw light upon some of the earlier chapters in the earth's crust. At present, the light is dim. "Let it grow."

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[1] Quart. Journ. Geol. Soc. November, 1880, p. 591.

IV.—Two more English Carboniferous Insects.

By Samuel H. Scudder, Esq.,
of Cambridge, U.S.A.

By the kind intervention of Sir William Dawson, the Rev. H. H. Higgins has sent me two new Carboniferous Insects of sufficient interest to bring to the attention of English palæontologists. They are both preserved in the Liverpool Museum, one having been presented to it by Major Chambers as long ago as January, 1858; while the other was mentioned by Mr. Higgins in his presidential address to the Liverpool Naturalists' Field Club in 1871, and figured on the plate of the Ravenhead fossils in the Liverpool Museum (fig. 15) which accompanies it. Both the wings are gigantic.

The recent discoveries of M. Charles Brongniart in the Carboniferous rocks at Commentry in France have occasioned something of a revolution in our ideas concerning early insects, having shown among other things the presence in Carboniferous deposits of a group of walking sticks of an ancestral, generalized type (see Geol. Mag. 1879, Vol. VI. pp. 97–102, Pl. IV). Their wings, for instance, so closely resembled in their neuration the general structure of neuropterous wings, that up to his discovery detached wings, now known to belong to this group (*Dictyoneura*, etc.), were always and unhesitatingly classed as neuropterous. M. Brongniart has also discovered fragments of a gigantic wing which is either the same as, or closely allied to, one from Derbyshire, which, from a basal fragment, I described as *Archæoptilus ingens* (Geol. Mag. 1881, Vol. VIII. p. 295), showing that this also is to be referred to the same group. Most probably the fragment, also of the base of a wing, which Mr. Higgins figures from the Lancashire deposits, belongs to the same category; but it is rather too incomplete to speak of it with confidence. Not unlikely, when more complete examples are found, it may prove to be a second and smaller species of *Archæoptilus*.

Of the other specimen, we may speak with more confidence, as it is much better preserved, showing indeed the greater part of the wing. It belongs unquestionably to this same group of *Protophasmida*, as Brongniart calls it, and bears a considerable general resemblance to the still larger form which he has named *Dictyoneura Monyi*, belonging indeed in the same division of the family, where the scapular nervure is simple. It may be known under the name of *Ædœophasma*[1] *anglica*.

In its generic features it is characterized by the great breadth of the wing, which is broadest in the middle, its unbranched scapular vein (which brings it in the immediate vicinity of *Goldenbergia*, and especially of the group to which *Dictyoneura Monyi* and *D. Goldenbergi* of Brongniart belong), and the abundant offshoots of the lower veins, which in the distal halves are closely crowded and repeatedly forked, while in the basal half of the wing, the veins are comparatively distant. The costal margin is regularly and gently convex. Notwithstanding the great extent of the wing, the externomedian and anal are the only branched veins, and the former occupies almost the entire wing; its lowest branch originates close to the base of the wing (not seen in the specimen), and although it runs at a wide distance from the simple internomedian vein, it is only shortly before the middle of the wing that it throws off its first offshoots, which part from the branch at a wider angle than elsewhere in the wing; for nearly all the subordinate nervules are closely crowded together. The anal area extends far beyond the middle of the wing, is comparatively narrow, and filled with very longitudinal branches. Moderately distant cross-veins fill the wing, mostly straight and transverse, but in the broader interspaces irregular and often branching. The length of the fragment is 75 mm., and its width 40 mm. The outer margin is everywhere broken by reaching the end of the nodule, but the probable length of the wing was 130 mm., its breadth hardly, if at all, greater than is preserved. The expanse of wings of the living insect must have been somewhere from 250 to 300 mm., or somewhat more than ten inches.

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[1] Αἰδοῖος, *Phasma.*

The exact locality from which the specimen was obtained is not known, but Mr. Higgins says that it certainly comes from the Liverpool Coal-field. The rapidly increasing number of Carboniferous winged insects in other parts of the world should stimulate search in Great Britain, for the actual number of forms known to-day is probably double what it was fifteen years ago. These are the first *Protophasmida* recorded from Great Britain.

V.—On the Successive Stages of Slaty Cleavage.

By Alfred Harker, B.A., F.G.S.,
Demonstrator in Petrology in the Woodwardian Museum, Cambridge.

SINCE a "shear" is mathematically the same as a compression in one direction with a *compensating* expansion in a direction at right angles to it, the consideration whether slaty cleavage can be ascribed to movements of this character resolves itself into the question whether the cleaved rocks have or have not suffered a total diminution of bulk. The most convenient way of treating the question is by discussing, as I did in my former paper (p. 15), the form of the "ellipsoid of distortion." The ellipsoid produced by a pure shear would be one of three unequal axes, of which the second or mean axis would be a geometric mean between the other two: whereas, if the expansion did not compensate the compression, the second axis would be greater than this geometric mean, and if the expansion were slight, the second and greatest axes would be nearly equal. The facts seem to accord with the latter supposition, and the diminution of bulk thus indicated agrees with what might be *a priori* expected.

Consider, for instance, the probable behaviour of a rock composed largely of fragments of long and flat forms, having initially no cleavage structure, and operated upon by a continued longitudinal pressure which for clearness we may imagine as operating in a horizontal direction. It appears manifest that the first result of such pressure would be a horizontal compression of the rock, involving a corresponding decrease of bulk, and effected by the closer packing of the constituent fragments, accompanied by the expulsion of the greater part of the interstitial water. Such packing, facilitated no doubt by the fragments slipping over one another, would tend to arrange them in vertical planes perpendicular to the direction of the pressure, thus setting up a cleavage structure. The ellipsoid of distortion would be one in which the greatest and second axes would be nearly equal. This is the case in the Devonian slates investigated by Dr. Haughton.

But there must evidently be a limit to the process of packing just described, and when this was reached, since there could be no further decrease of bulk, continued pressure would give rise to a vertical expansion of the mass compensating the horizontal compression. The movement in this second stage of the process might be justly described as shearing. It would increase the greatest axis of the ellipsoid of distortion and proportionately decrease the least axis. At the same time it would produce a more perfect cleavage structure by arranging the long and flat-shaped fragments more exactly in vertical planes perpendicular to the direction of pressure. This is the case in the Llanberis and Borrowdale slates observed by Sorby and Sharpe.

As a still further result, a more intense pressure would probably bring about mineralogical and chemical as well as merely mechanical changes, the rock losing its eminently fissile character by becoming foliated. This connection between cleavage and foliation was long ago pointed out by Darwin in South America. The obliteration of fossil remains in such foliated rocks leaves us no means of testing the precise character of the distortion they have undergone, but the ellipsoid expressing such distortion would doubtless be excessively elongated and flattened.

The difference between the processes sketched above and the ideas developed in Mr. Fisher's papers in this MAGAZINE is evident. He maintains, in effect, that the whole movement which produced slaty cleavage in a rock was one of shearing. As regards Mr. Fisher's paper in the April Number, there is one point raised, to which, as he says, I have hitherto made no allusion, viz. the relation of cleavage to the folding of the strata in which it occurs. Mr. Fisher would argue that since the direction of the cleavage-planes seems to be almost independent of the varying dip of the beds, the origin of the cleavage structure must be posterior to the folding of the strata. Granting this, however, it does not follow that the two things were independent. As Mr. Fisher points out in the same paragraph (p. 177), they are two distinct modes of satisfying compression, and therefore we need not expect to find them proceeding simultaneously. That contortion of the strata should precede cleavage is a matter of no surprise, if the latter involve an actual condensation of bulk while the former is a mere change of position. In accordance with this we frequently find contortion without cleavage, but cleavage without contortion never. In many cases also there is clear evidence that contortion on a minute scale is a first step towards a cleavage structure, which is rather different in character from that described at the beginning of the present article, though similar in its effects. This has been studied by Dr. Sorby in the slates of Liskeard and other places, and is described and figured by Heim under the name *Ausweichungsclivage.* I suppose Mr. Fisher refers to something of the same kind when he speaks of a frilled schist passing into a rock showing schistose cleavage (p. 176).

In conclusion, I should like to correct a misapprehension of Mr. Fisher's with reference to my former paper. I have always supposed the direction of cleavage to indicate the plane perpendicular to the maximum compression (*i.e.* the principal diametral plane of the ellipsoid of distortion), and not the direction of shearing (which would be, on Mr. Fisher's hypothesis, one of the circular sections). For a great amount of shearing, however, the two planes would make only a small angle with one another.

My diagram, like that of Mr. Fisher to which it corresponded, was not intended to have any relation to the surface contour of the land.

REVIEWS.

I.—Lithological Studies, a Description and Classification of the Rocks of the Cordilleras. By M. E. Wadsworth. (Memoirs of the Museum of Comparative Zoology at Harvard College, vol. xi. pt. 1, pp. 208 and xxxiii. plates viii.) Cambridge, Mass., Oct., 1884.

THE science of petrology, or petrography,[1] as Dr. Wadsworth would prefer to call it, has been cumbered, more perhaps than any other, by crude hypotheses and wide generalizations founded on slight bases of facts. To students weary with this kind of literature Dr. Wadsworth's Lithological Studies will be a welcome refreshment. The method of treatment is logical, which must command respect even if it failed to convince; the style is clear, and not seldom incisive. Dr. Wadsworth in controversy "calls a spade a spade," and bursts the bladders of tumid hypothesis with scant ceremony.

The present volume is but an instalment of a work which must extend to a considerable length. Its basis, as implied by the title-page, is the lithological collection accumulated by Dr. Whitney in the process of the (uncompleted) Survey of California, but in dealing with the more basic portion of these rocks in the present part Dr. Wadsworth has found it needful to carry his investigations far beyond the limits of the Cordilleras. The opening chapter treats briefly of the structure of the earth. The author thinks it probable that the inmost portion concerning which we have any data is composed of iron, with

[1] On the analogy of the names of all the other sciences there can, we think, be no question that this use of the term petrography, whatever may be the authority in its favour, is wrong. Dr. Wadsworth uses petrography as inclusive of lithology and petrology, the latter dealing with the characters of rocks observed in the field only: but surely this is merely petrography; the science is petrology.

or without nickel. As we recede from the centre, pyrrhotite is united with these; then olivine, enstatite, and sometimes diallage, in varying proportions, are the chief constituents. From this zone we pass into the basaltic rocks, then into the andesites, lastly into the various representatives of the most acid rocks. But, owing to various causes, these original zones have been much disturbed and mingled, so that at the present time a definite and regular sequence of igneous rocks is hardly to be expected. The author passes on to consider the question of whether the so-called igneous rocks are portions of the original magma of the earth or of sedimentary deposits in a condition of aqueo-igneous fusion. Dealing with this question after a strictly logical method, he shows that the latter view rests rather on hypothesis than on fact: to it "the field evidence, as well as the microscopic, is opposed *in toto.*" Dr. Wadsworth also repudiates the attempt to classify igneous rocks by their geological age, while he admits, of course, that lapse of time has in many cases produced subsequent modifications, and there is a possibility that some peculiar conditions prevailing at the time of consolidation may have had an influence. Some valuable remarks are then made upon certain of the more important rock-structures, as joints, cleavage and foliation, and on misconceptions which have arisen concerning them. The author then passes on to consider the chemical analysis of rocks, prior to which he points out the frequent misuse of this mode of investigation, due to neglect of the past history of the rock and of proper precautions in selecting specimens for analysis. An interesting critical sketch is given of the history of opinion in regard to the species of the felspar group of minerals, the author coming to the conclusion that "a systematic classification cannot properly be based on any such variable, indeterminate materials." In his opinion a similar relation and a like variability seems to exist in the enstatite-hypersthene-pyroxene-amphibole group of minerals. The author then states his views as to the principles upon which a rock classification should be founded. These are too lengthy for quotation in the space of a brief notice, but the following extract may be given as indicating the dominant principle: "All the petrological, lithological, and chemical characters should be used in determining rock species; that is, the rock as a whole and in all its relations should be considered. The classification should be a natural one, and therefore empirical, embodying all known characters of the rocks."

The second chapter in the volume deals with the Siderolites and Pallasites. The former name is applied by the author to rocks composed chiefly of iron—either native or in its secondary states, as magnetite, hematite, menaccanite, etc., with or without nickel, graphite, etc. It includes masses of iron and iron-ore that have fallen as meteorites, with some of eruptive origin, but excludes veins or chemical deposits of iron-ore. The name Pallasite is given to masses of iron (perhaps oxidized) containing olivine and occasionally felspar, enstatite, diallage, etc. Those at present recognized appear to be of meteoric origin, but Dr. Wadsworth regards a variety, to which he gives the name Cumberlandite, as eruptive.

The third chapter deals with the Peridotites, rocks of both meteoric and terrestrial origin. In his introductory remarks, the author expresses the opinion, in which most of those who have studied the subject will agree, that the Peridotites are essentially of one type, viz. rock composed of olivine with sundry adventitious minerals, as magnetite and members of the spinel group, enstatite, augite, etc.; but inasmuch as varieties are generally admitted, he accepts or proposes the following varietal subdivisions and names: olivine mainly = *Dunite* : olivine + enstatite = *Saxonite* : olivine + augite = *Picrite* : olivine + diallage = *Eulysite* : olivine + enstatite + augite = *Buchnerite* : olivine + enstatite + diallage = *Lherzolite.* In regard to these subdivisions we must venture a slight criticism. The name Eulysite is generally (and we believe was first) applied (as afterwards used by the author) to the peridotite from Thunaberg, in which a fair proportion of garnet is present; this we take to indicate a not unimportant difference in chemical composition. We doubt, also the possibility of separating the peridotites with diallage from those with augite. Our own specimens of *Lherzolite*, taken from the typical localities, contain augite, and the diallage is not a strongly-marked form. We should, therefore, prefer to give distinctive names to the olivine-augite, and the olivine-enstatite-augite rocks only, prefixing diallage as an epithet in cases where that variety of pyroxene happened to be well marked. If, however, it is considered desirable to maintain this distinction, which indeed may be defended by the use of the term 'gabbro,' as distinct from dolerite, then we think Lherzolite may fairly be retained for the augite-bearing variety. Picrite also, we think, has more commonly been applied to rocks in which the pyroxenic constituent dominates over the olivine, and a little felspar is not seldom present—that is to an augite- (or hornblende-) olivine rock, rather than to an olivine-augite.

Dr. Wadsworth then passes on to describe a large number of peridotites from various parts of the world, both terrestrial and meteoric, as well as serpentines, the relations of which to peridotites are clearly indicated. A discussion of the asserted olivine-schists of the Troad is inserted here, which will be of use to the student after the rash statements which have been made concerning these rocks. We are not surprised that Dr. Wadsworth is convinced that the schists are derived from the olivine-rock, and not the olivine-rock from the schists; the latter origin is opposed to such a number of facts, that nothing but the clearest evidence could be held to substantiate it, and this is certainly not forthcoming. The last chapter deals with the basalts, but only those of meteoric origin are discussed here.

Long and extremely valuable tables of chemical analyses follow; the first indicating the relation of chromite and picotite, the others the complete analyses of a large number of the rocks discussed in the preceding chapters. The plates illustrative of some types of these are well executed, and will be found valuable. As no group of rocks has been more maltreated by speculative geologists than the peridotites, Dr. Wadsworth's volume will be a boon to the perplexed student, and a valuable work of reference to every petrologist (or petrographer?). T. G. B.

II.—Fauna der Gaskohle und der Kalksteine der Permformation Böhmens. von Dr. Anton Fritsch. Band I. heft. 4. (Prag, 1884.)

Fauna of the Gas-Coal and Limestone of the Permian Formation of Bohemia.

THE fourth part of Dr. Fritsch's work completes the first volume, which extends to 182 pages, illustrated with 116 figures printed in the text, and 48 coloured plates. It is a work for which naturalists will be grateful, and which has already won for its author the kindly regard and esteem of all who are able to appreciate his labours. Professor Fritsch begins with an account of the family Hyalonomidæ, which is made to include Dawson's genera *Hyalonomus* and *Smilerpeton;* and four genera of the author's named *Hyloplesion*, *Seeleya*, *Orthocosta* and *Ricnodon*, which are fully described.

Hyloplesion is a slender lizard-shaped amphibian. Its skull is broad, tapers anteriorly, and is rounded in front. The orbits for the eyes are placed anteriorly. The cranial bones are smooth, with a few small scattered pits. The teeth are small, slender, smooth, and even. Traces of the gill arches are found. The thoracic vertebræ have the spinous processes expanded in longitudinal fans. The ribs are curved, five times as long as the vertebræ, with both capitulum and tuberculum. The whole body was sheathed in scales, and on the abdomen these have a thickened posterior margin, but are only one-third the size of those on the dorsal region. Prof. Fritsch points out the resemblance of this type to *Hyalonomus*; but because that genus is at present so imperfectly known, and the remains show some differences in the vertebræ, teeth, and other organs, a new genus is founded. The only species is *Hyloplesion longicostatum.* Its remains are recognized by the form of the scales, vertebræ, and ribs. The ovate scales which are very small on the somewhat short tail are distinguished by dichotomously branching radiating ribbing. Scales appear to have covered the bones of the skull. Those on the abdomen appear to have been subquadrate. In the skull the parietal foramen is large, and placed toward the anterior third of the large parietal bone which however is blended with the frontal. The skeleton is well ossified. In the upper jaw there are about 13 teeth, of which the six in front are the largest. The jaw is short and only extends under the eye. The skull bones, however, are more or less scattered, and are described in detail.

There are about thirty vertebræ anterior to the pelvis, and forty in the tail. The notochord is continuous through the concave terminal cups of the centrum. The zygapophyses are distinct in the earlier vertebræ and the neural spine elongates lower down the back. The sacral vertebræ have no distinctive characters. The caudal vertebræ are short and wide, and have no ribs. The pectoral and pelvic arches and limbs are imperfectly preserved. There were five digits, terminating in clawed phalanges.

The genus *Seeleya* is founded on a slender amphibian with a large head and a short tail. The skull is triangular, and rounded in front. The teeth in the premaxillary bone are larger than those in the maxillary; they are smooth, and have large pulp cavities. All the palatal bones are strongly denticulated. The only species known is *Seeleya pusilla*. Like the preceding type, it is covered with thin oval scales, which are dichotomously ribbed.

Only the under side of the skull is exposed. There are four large slender smooth teeth in the premaxillary. In the maxillary bone there are 10 or 12 teeth. In the lower jaw 18 teeth are seen in the dentary bone. The vomer carries many small teeth. The parasphenoid has a slender anterior spine and a small posterior quadrate shield. Triangular bony plates tapering anteriorly lie on each side of the spine of the parasphenoid, and fill in the space between that bone and the curved pterygoid. This plate, which carries scattered teeth like those on the pterygoid, is regarded by the author as the vomero-palatine. The notochord, which is narrow, terminates anteriorly beneath the parasphenoid in a fusiform mass, which the author regards as material out of which the basisphenoid is to be developed. But he doubts whether the cranial portion of the notochord may not be in direct connection with the vertebral portion as in bony fishes, since such connection would account for the circumstance that he has never been able to distinguish the two lateral condyles which are presumed to exist. But it seems to me that if the discontinuous character of the notochord is established, it would tend to show that the segmentation of the protovertebræ in development was not complete anteriorly, and that the posterior half of the body of the basioccipital centrum may perhaps unite with the body of the first vertebra, while the anterior element remains united to the basisphenoid portion of the notochord. And if so, the circumstance would help to explain the relatively great development of the exoccipital bones characteristic of modern amphibians.

The lower jaw is strongly developed and runs the entire length of the skull. There are slight indications of branchial arches.

There are 60 vertebræ; of which 33 belong to the trunk, and 27 to the tail: they are one and a half times as wide as long. The neural arch extends along the centrum, and has the neural spine extended both in front and behind in a hatchet form. Similar processes are found in the early caudal vertebræ, but from the fortieth to the fiftieth they become smaller and lose the antero-posterior expansion. The first 20 ribs are about four times as long as the vertebræ, moderately curved, and have capitulum and tuberculum equally developed. The later vertebræ become rapidly shorter. In the tail the ribs have but one head. The hinder extremity is one and a half times as long as the fore limb.

The genus *Ricnodon* is instituted for a small amphibian with a large head, having the cranial bones pitted, and with strong limbs which are equally developed anteriorly and posteriorly. The parasphenoid and pterygoid are armed with teeth. The scales are large. The genus includes three species, named *Ricnodon Copei*, *R. dispersus*, and *R. trachylepis*, which are associated by the author with some doubt.

Ricnodon Copei has four teeth in the premaxillary bone; they are slender, with blunt crowns, furrowed, with a few vertical depressions. The maxillary teeth are smaller. The madibular teeth are not half as long as those in the maxillary. The pterygoid has a remarkable sickle-shaped form. An internal process meets the expanded base of the parasphenoid. The whole palatal curved portion of the pterygoid is densely studded with small teeth like shagreen. The vomer is probably similarly covered with teeth. In the vertebral column the neural arch is united only to the anterior third or half of the centrum. The ribs are hollow, three times as long as the vertebræ, and have heads. The scales are much longer than the vertebræ, and are mostly about three millimètres in length. They are very finely ribbed and somewhat granulated towards the extremity.

Ricnodon dispersus is distinguished from the preceding species chiefly by the scales, which have the hinder border thickened and serrated. The furrowed extremities of the premaxillary teeth are like those of the foregoing species. *Ricnodon trachylepis* has scales similar to those of *Ricnodon dispersus*, but the smaller scales, regarded as abdominal, are nearly square, and obliquely keeled, so that the lesser portion is smooth and the large division tubercled.

The genus *Orthocosta* is formed for an elongated slender amphibian with unusually elevated spinous processes, which are constricted at the base and expand in a fan-shape above. The ribs are slender and short. The caudal vertebræ are short, with well-developed spinous processes; the earlier vertebræ carry ribs. The dorsal scales are oval and sculptured. The abdominal scales are obliquely widened and thickened on the hinder border. *Orthocosta microscopica* is founded on remains so minute that the entire animal could not have exceeded 23 mm. in length; yet all the parts are completely ossified. The dorsal scales are as long as the vertebræ, ovate, ribbed; the ventral scales are transversely widened, and have the hinder margin thickened like a rod. Twenty-one trunk vertebræ are preserved, which agree in form with those of *Hyloplesion.* The neural arch is higher than the centrum, and is limited to its anterior third. The femur is three times as long as a dorsal vertebra.

A lower jaw is referred from the character of the teeth to *Lepterpeton.*

The last family discussed in this part is the Microbrachidæ, represented by the genus *Microbrachis* and three species. These animals have the body slender, with anterior limbs small, and cranial bones sculptured with radiating and reticulate grooving. The middle thoracic plate is broad with a long stalk. The abdominal surface is defended with scales.

Microbrachis Pelikani has the upper bones of the skull marked with radiating grooves which form a network. The body is slender, with the tail half as long as the body and the anterior limbs very small. The entire length is about 150 mm. The scales which were of large size were sculptured much as in the preceding species.

The orbits of the eyes are oval in the anterior third of the skull and converge forward. The foramen parietale is nearly in the middle of the parietal suture.

The premaxillary carries 6 or 7 sharp teeth with furrowed points The maxillary carries 27 pointed teeth with the smallest in front The palatine process carries small denticles. There are 26 teeth in the mandible.

On the under side of the skull the parasphenoid has a rhomboidal shield, and an anterior stalk marked with four longitudinal furrows and pits at its base which may indicate a group of teeth. The pterygoid bone is marked with oblique fan-like grooving and may have carried a few teeth. The orbital ring is formed by 7 or 8 plates.

There are 36 vertebræ in the trunk, and about the same number in the tail. The caudal vertebræ are wide and short. The thoracic vertebræ have a short transverse process to which the ribs are attached. The middle thoracic plate is relatively small, and consists of a thin, fan-shaped plate, with the margin prolonged into thirty rays; the stalk is scarcely stronger than one of these rays.

The humerus is about one and a half times as long as a vertebra which is only half its relative length in *Hyloplesion*. The fore arm is as long as a vertebra. The carpal bones are unossified. The femur is twice as long as the humerus; and the tibia and fibula half as long as the femur.

Microbrachis mollis.—In this species the radiating furrows on the cranial bones are simple and rarely dichotomous. There are 12 teeth in the maxillary bone. The animal was about 16 cm. long and closely resembled the foregoing species, but had the skull wider with a round snout. The teeth are stronger and less numerous There are 38 thoracic vertebræ and 20 to 25 caudal vertebræ. The neural arch is at first low, but subsequently becomes more elevated in the dorsal region.

Microbrachis (?) *branchiophorus* is only known from the skull which has the bones furrowed, with a parasphenoid of the *Microbrachis* type, except that it appears to carry two long rows of teeth on the shield, which has a distinctive emargination. The skull was as wide as long. The parietal foramen is transversely wide. There are 12 teeth in the maxillary, and 18 in the mandible. The pterygoid carried teeth.

All the Amphibians which have been described in this volume are devoid of traces of labyrinthic structure in the teeth. The author concludes that the presence of branchial arches or a parasphenoid bone prove the remains to have been truly amphibian; but they can in no sense be regarded as the ancestors of living *Urodella*; and their true position in classification needs further investigation. The next volume will be chiefly devoted to amphibians in which the teeth show a labyrinthic structure. We would express our congratulations to the author on the completion of the first volume of his arduous and admirable labours. H. G. SEELEY.

III.—Ueber Fisch-Otolithen, insbesondere ueber diejenigen der norddeutschen Oligocän Ablagerungen. Von Herrn Ernst Koken in Berlin. Aus der Zeitschrift der Deutschen geologischen Gesellschaft, 1884, pp. 500—565, Tafel ix.—xii.

On the Otoliths of Fishes, more Particularly on those of the Oligocene strata of North Germany. By Ernst Koken. Journal of the German Geological Society, 1884.

THROUGHOUT the Oligocene strata of North Germany, fossil bony fishes are, to a great extent, represented merely by their detached minute otoliths or ear-bones, and the author in this paper has endeavoured to ascertain the groups of fishes to which these bodies belong. As the otoliths of existing fishes have not been described by zoologists with sufficient detailed precision to be of service for comparison with the fossil forms, the author has studied those of different living species belonging to 60 genera of fishes, and he finds that their characters are more constant in different groups, and therefore more reliable for purposes of classification, than many of the other skeletal structures which are generally employed for this purpose.

The otoliths are laterally compressed, elongate, to nearly circular bodies, curved, so that the outer side is mostly concave, whilst the inner is convex. On the convex inner side, extending from the anterior to near the posterior margin, is a long impression or sulcus, and on the various modifications of this sulcus the more distinctive characters of the otoliths rest. The concave outer side of the otoliths is marked by radiating folds or tubercles, or by a combination of both. The otoliths are formed by successive concentric layers of minute crystalline rods of calcite, and these minute particles have a definite angular disposition in relation to radial lines extending from the centres of the otoliths. On this minute interior structure the surface characters depend, and it is constant for each species.

Genuine otoliths are only present in the auditory organs of Teleosteans and Ganoids; in Sharks, Rays, Chimeroids and Cyclostomi, there are only loose irregular aggregations of small crystalline particles of calcite. From the otoliths present in the Oligocene strata of North Germany, the author has determined 21 different species of fishes, belonging to 8 families, viz., the *Gadidæ, Percidæ, Apogonidæ, Trachinidæ, Sciænidæ, Sparidæ, Triglidæ,* and *Pleuronectidæ.* Of these, the *Gadidæ* or Cod family is distinctly predominant, and it is represented by 7 species, of which 2 belong to *Gadus* itself. Professor Prestwich also records that the otoliths from the Norfolk and Suffolk Crag belong to *Gadus* and allied genera.[1]

Otoliths very seldom occur in their natural position in the entire fossil skeletons of fishes, though a few cases are known from beds in which fossil fishes are very abundant and well preserved. On the other hand, they are by no means uncommon in beds in which no other remains of fishes are met with. This fact may perhaps be explained from the facility with which they would fall out from the skull and sink to the sea-bottom on the decomposition of the s in which they are inclosed, whilst the rest of the skeleton m drifted to distant localities; the harder structure of the would also favour their preservation, and enable them to re fluences which would completely destroy the softer bones skeleton.

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[1] Quart. Journ. Geol. Soc. vol. xxvii. p. 132, 1871.

IV.—TRANSACTIONS OF THE CUMBERLAND AND WESTMORLAND CIATION. No. IX. 1883–84. Edited by J. G. Goo F.G.S., F.Z.S.

PART VIII. of these Transactions was noticed in the GEOI MAGAZINE for April, 1884. The number now before t tains an interesting and suggestive article on "The Penritl stone," by Mr. J. G. Goodchild. This deposit occurs at the the New Red Sandstone series, and contains conglomerati locally known as Brockram. The lacustrine origin of the sa is advocated by Mr. Goodchild, and he considers that the Br may have been produced by the aid of shore-ice in the ol Most striking is his conclusion that not only the Pennine ch also the Lake Mountains were upheaved after the New Red

Mr. T. V. Holmes furnishes some "Notes on the best locality beneath the Permian Rocks of North-west Cumberland." Donald, of Stanwix, contributes "Notes on some Carbon Gasteropoda from Penton and elsewhere," describing one new *Aclisina costatula*. The paper is accompanied by a plate. Leitch figures some remains of *Bos primigenius* in a plate acco ing some "Notes on the Geological Formation and Fossils Silloth New Dock." Mr. Goodchild gives the concluding par Contributions towards a list of the Minerals occurring in Cum and Westmorland. Useful local scientific notes and memoran clude the volume.

V.—CONTRIBUTIONS TO THE NATURAL HISTORY OF THE BER Part I. The Geology of Bermuda, by WILLIAM NORTH Bull. Nat. Mus., No. 25, pp. 1–32, pl. ii.–vi. (Washington,

IN recording his own observations and summarizing those predecessors (notably J. Matthew Jones, Sir Wyville Th and Major-Gen. Richard J. Nelson, R.E.), Prof. Rice descri Bermudas (long. 64° 40′—65°, lat. 32° 10′—32° 20′) as an fect atoll formed about an undescribed nucleus during a pe submergence and modified by (1) elevation during which the character was largely obliterated and extensive drift sa deposits were accumulated, and (2) subsequent depression which the wind-blown sand deposits were in part removed were submerged, and lagoons were formed. These oscillati hypothetically correlated with those of the New England Qua period, and the last is shown to be pre-historic. The rocks nized are (1) coral reef-rock, (2) beach sand-rock, derived fr *first by* wave-action, (3) drift sand-rock derived from both tl *ceding by* Æolian action, (4) "red earth" derived from all

foregoing by decomposition, and (5) small quantities of erratic material variously derived. The fossils appear to belong to recent forms.
W. J. M.

VI.—California State Mining Bureau.

THROUGH the courtesy of Mr. Henry G. Hanks, State Mineralogist, we have received a copy of the Fourth Annual Report on California, which he has prepared for the year ending May 15, 1884. This report deals with information, general and statistical, in relation to the Agricultural, Commercial, Manufacturing, and other resources, interests, and industries of the State. The chief part of the work is, however, devoted to a Catalogue and Description of the "Minerals" of California as far as known, with special reference to those having an economic value. This Catalogue contains material of much general as well as scientific interest. Thus in reference to Petroleum, there are accounts of its different forms, of what the ancients knew about it, and of its early history, origin, and uses. Coal is noticed under the heading "Mineral Coal," which includes Lignite, Anthracite, Ionite, etc. Ionite is a hydro-carbon mineral found in Ione Valley. Considerable space is naturally devoted to Gold, its properties, alloys, chemistry, and geology, as well to the history of its discovery. Iron, Quicksilver, Copper, Lead, and Silver are among the more abundant metals. Chromite, including accounts of chrome ores and chrome steel, and Iridium are noticed. Diamonds also are mentioned, and an account is given of Diatomaceous Earth, with notes on its localities and uses, and a list of the Diatoms found in it. There are also interesting notices of Borax, of Lime, Building Stones, of Clays, together with accounts of brick manufacture and notes on Ceramic art. Under the heading of Sulphur, we find accounts of its uses, its metallurgy, of the mines and works, of consumption and supply, etc.; and under the heading Quartz, there are notes on the Amethyst, Buhr Millstone, False Topaz, "Quartz Jewelry," Glass and Glass making in California.
H. B. W.

VII.—The Young Collector's Handbook of Fossils. By Bernard B. Woodward, F.G.S. Pp. 32. Price 1*d*. (London: Swan Sonnenschein & Co.)

THIS concise and carefully-prepared little work contains notes on the principal formations represented in England and Wales, with a few illustrations of the fossils; and also remarks on the method that should be followed in collecting and arranging specimens. It is written by one who is evidently an enthusiastic Naturalist, and it is therefore calculated to awaken the interest of those who have not previously devoted attention to geology. The exceedingly low price is likely to ensure for the work an extended circulation, and perhaps the question of cost may have influenced the author in omitting from his "Works of Reference" the important Text-Book of Geology by Dr. A. Geikie, of which a second edition is just announced.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—[1] March 11, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "The Granitic and Schistose Rocks of Donegal and some other Parts of Ireland." By C. Callaway, D.Sc., F.G.S.[2]

The author first recalled attention to the current theories on the nature of the Donegal granitic rock, one which described it as a highly metamorphosed portion of a sedimentary series, another which regarded it as a mass of Laurentian gneiss. In his view, however, it was a true igneous granite, posterior in age to the associated schists. In six districts examined it was intrusive and sent out veins. The apparent interstratification with bedded rocks was explained as a series of comparatively regular intrusions. Where the granite was seen in contact with limestone, the latter contained garnets and other accessory minerals. No gradation could be discovered between the granite and any other rock, the junctions (even in the case of small fragments of schist immersed in granite) being well marked.

The granite was distinctly foliated. In some localities there was merely a linear arrangement of the mica; but near the western margin of the granite promontory there was a striping of light and dark bands, the colour of the latter being due to the abundance of black mica. The gneissic structure was attributed to lateral pressure, the existence of which in the associated strata was seen in the conversion of grits into schist-like rocks, in the production of cleavage in beds of coarse materials, in the crushed condition of some masses, in the overthrow of folds, and in the production of planes of thrust. The direction of the pressure was perpendicular to the planes of foliation in the granite.

The schistose rocks of the region were divided into two groups. The *Lough Foyle series* consisted of quartzites, quartzose grits with a mineralized matrix, slaty-looking schists, fine-grained satiny schists, black phyllites, and crystalline limestones and dolomites. The semicrystalline condition of most of these rocks was characteristic. This series was well seen at Londonderry and on Lough Foyle, and formed a broad band striking to the south-west. These rocks were compared with similar types in the Hill of Howth (north of Dublin), near Aughrim (co. Wicklow), and South of Wexford. The Leinster semicrystalline masses were quite unlike the Wicklow Cambrians, and bore a strong resemblance to the slaty series of Anglesey. They were lithologically intermediate between the Donegal and Anglesey groups, and from a comparison of all these areas the author referred the Lough-Foyle Series, with some confidence, to the Pebidian system. The prolongation of the Lough-Foyle rocks into the Grampian region was well known, and Ireland thus served to connect some parts of the Scottish highlands with South Britain.

[1] This abstract was unfortuately omitted from the last number.—EDIT. GEOL. MAG.

[2] See paper by the same author, p. 258.

The author was not prepared to correlate this Donegal series with any American group; but the lithological affinities were rather with the Taconian than with the Huronian.

The *Kilmacrenan series*, in which the granite is intrusive, was described as crystalline, and older than the Lough-Foyle group. It was mainly made up of micaceous, quartzose, hornblendic, and hydro-magnesian schists, quartzites, and crystalline limestones. There were no indications in these rocks of a metamorphism progressive in the direction of the granite. This series was lithologically similar to the Montalban system.

Fifty-five microscopic slides of Donegal and Leinster rocks had been examined by Prof. Bonney, whose observations confirmed those of the author both as regards the nature and relations of the granite and the general characters and state of crystallization of the two schistose groups.

2. "On Hollow Spherulites and their Occurrence in Ancient British Lavas." By Grenville A. J. Cole, Esq., F.G.S.

Many of the felstones of North Wales have been shown to be altered lava-flows of an originally glassy type. In several localities, as in the Pass of Llanberis, at the foot of the Glyder-fawr, these rocks contain numerous nodular bodies, from $\frac{1}{10}$ inch to some inches in diameter. The smaller varieties have the appearance of spherulites, but the larger are very often hollow, their cavities being partly filled with minerals deposited by infiltration. The lavas thus receive a scoriaceous character, and have been described as slaggy and vesicular. Similar structures, such as the "Lithophysen" of von Richthofen, occur in rocks of much later date, and the theory advanced by Szabó, that their cavities have been formed by the weathering-out of the centres of spherulites, has been pretty generally accepted. A consideration of hollow spherulites of very different sizes from Iceland, Lipari, and the Yellowstone area, tends strongly to support this view, those portions that show radial structure being most easily attacked by the agents of decomposition. The merely concentric coats of the spherulite, on the other hand, consisting mainly of globulitic particles and glass, remain but little altered, and a series of hollow shells may arise one within the other, by the complete removal of the intervening radial matter. The frequent association of perlitic structure and hollow spherulites in the same rock may be due to the number of channels provided in such cases for the passage of water or acid vapours.

Structures resembling the "Lithophysen" of Hungary occur in the altered rhyolites of the Wrekin, the cavities being filled with quartz; and the hollow nodules of the Silurian felsites in the Pass of Llanberis prove, on microscopic examination, to have been originally spherulites. Many of these nodules show marked radial structure in their central areas; and every gradation exists between the solid varieties and those which have been hollowed out or replaced by products of infiltration. The completion of such a process of alteration might cause a rock not originally vesicular to be regarded as an ordinary amygdaloid.

II.—April 15, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "A General Section of the Bagshot Strata from Aldershot to Wokingham." By the Rev. A. Irving, B.Sc., B.A., F.G.S.

The author referred to earlier papers in the Geological Magazine,[1] in which the green colouring-matter so common in the Middle and Lower Bagshot strata of the London Basin had been attributed to the presence of vegetable débris and the materials resulting from decomposition of vegetable matter. The marked difference in this respect between these strata and the higher members of the series furnishes a clue to the conditions under which they were respectively deposited, the former being delta- and lagoon-deposits, the latter the deposits of a marine estuary. This implies a transgressive overlap of the upper portions of the Bagshot series upon the London Clay; and the present paper was devoted to a consideration of the statigraphical evidence of this overlap.

Sections were described in detail at Aldershot, Farnborough, Yateley, Camberley, Wellington College and the neighbourhood, and from the last-named place to Wokingham. From these, a general section was constructed to exact scale, both as to thickness of strata and altitudes, showing a relation of the Bagshot formation to the London Clay, which was inconsistent with the generally received idea of their conformability, and at variance with the mapping of the district as executed by the Geological Survey.

The importance of the Bagshot pebble-bed as a basement-line of the upper division of the Bagshot strata was shown, as was suggested by the author, so long ago as 1880.

The synclinal arrangement of the London Clay was shown to have been produced *before* the deposition of the Bagshot series, though a certain amount of movement (with a resultant amount of 150 feet of tilting in 13 miles from south to north) has since taken place.

2. "Notes on the Polyzoa and Foraminifera of the Cambridge Greensand." By G. R. Vine, Esq. Communicated by Thomas Jesson, Esq., F.G.S.

After commenting on the want of published information concerning the Polyzoa of the Cambridge Greensand, as shown by the fact that none are mentioned in Mr. Jukes-Browne's list of the fossils (Quart. Journ. Geol. Soc. vol. xxxi. p. 305), the author proceeded to explain the circumstances under which he had been entrusted with the whole of Mr. T. Jesson's collection from the coprolite-bed for description. The collection is large and important, and the Polyzoa contained exhibit a facies distinct from that of the Jurassic beds on the one hand and of the Upper Chalk on the other. There is but little similarity between the collection now described and the forms known from Warminster and Farringdon. The majority of the Cambridge-Greensand Polyzoa occurred unattached to any matrix; but several examples of attachment have been observed, chiefly to *Ostrea*, *Radiolites*, and species of *Cidaris*.

A list showing the range of the species described preceded the actual descriptions of the following kinds of Polyzoa and Foraminifera, with notes on their relations, etc. It included:—

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[1] See Geol. Mag. 1883, pp. 404–413, and 1885, pp. 17–25.

POLYZOA.

Stomatopora gracilis. Milne-Edw.
Idmonea dorsata, Hagenow.
Entalophora raripora, D'Orb.
———— *Jessonii*, sp. nov.
———— *striatopora*, sp. nov.
———— *gigantopora*, sp. nov.
Diastopora cretacea, Vine.
———— var. *lineata*, var. nov.
———— *fecunda*, sp. nov.
———— *megalopora*, sp. nov.

Lichenopora, sp.
———— ? *paucipora*, Vine.
Dromopora stellata, Goldfuss.
———— *polytaxis*, Hagenow.
Osculipora plebeia, Novall.
Truncatula, sp.
Membranipora cantabrigiensis, sp. nov.
Microporella, sp. (? *antiquata*.)
Lunularia cretacea, Defr. & D'Orb.

FORAMINIFERA.

Webbina lævis, Sollas.
———— *tuberculata*, Sollas.

Trochammina irregularis ?, D'Orb.
Textularia, sp.

III.—April 29, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On the Structure of the Ambulacra of some Fossil Genera and Species of Regular Echinoidea." By Prof. P. Martin Duncan, M.B. (Lond.), F.R.S., V.P. Linn. Soc., F.G.S.

After noticing the general knowledge which exists about the structure of the ambulacra in the Cidaridæ and the elaborate investigations of Lovén on the Triplechinidæ, the author brought before the Society the results of his own work with and without the cooperation of his fellow-worker in the description of the Echinoidea of Sind, Mr. Percy Sladen, F.G.S., and which referred to the Diadematidæ and the Arbaciadæ of the recent faunas. Starting with the knowledge of the construction of the modern Diadematidæ, the author investigated the genera *Hemipedina*, *Pseudodiadema*, *Pedina*, *Hemicidaris*, *Diplopodia*, and *Cyphosoma*. The necessity for the re-establishment of the genus *Diplopodia* was shown, and a new genus, *Plesiodiadema*, was founded. *Pseudodiadema*, shorn of the forms included in these genera, remains and differs more from *Diadema* than has been believed. The method of the growth of the great plates of *Hemicidaris* was explained, and the comparison between the peristomial plates of some of the Diadematidæ and the universal structure of the ambulacral plates in *Pedina* was made. The author considered that there are six types of ambulacra in the regular Echinoidea, so far as the group has been investigated, there still remaining much to be done. These types are the Cidaroid, Diadematoid, Arbacioid, Echinoid, Cyphosomoid, and Diplopodous. In conclusion the succession in time of the structures which characterize these types was considered.

2. "The Glacial Period in Australia." By R. von Lendenfeld, Ph.D. Communicated by W. T. Blanford, LL.D., F.R.S., Sec. G.S.

Although several previous writers have suggested that boulders and gravels found in different parts of Australia are of glacial origin, the evidence is vague and no clear proof of glaciation has been brought forward. During a recent ascent of the highest ranges in Australia, parts of the Australian Alps, the author succeeded in discovering a peak which he named Mount Clarke, 7256 feet high, and in finding traces of glaciation in the form of *roches moutonnées* throughout an area of about 100 square miles. The best-preserved of the ice-worn surfaces were found in a valley named by the author the Wilkinson Valley, running from N.E. to S.W., immediately south of Müller's Peak and the Abbot Range. No traces of ice-action were found at less than 5800 feet above the sea.

The rocks showing ice-action are all granitic, and the fact that the surfaces have been polished by glaciers is said to be proved by the great size of such surfaces, by their occurrence on spurs and projecting points, by many of them being worn down to the same general level, and by their not coinciding in direction with the joints that traverse the rock.

In conclusion the author briefly compared the evidence of glacial action in Australia with that in New Zealand.

3. "The Physical Conditions involved in the Injection, Extrusion, and Cooling of Igneous Matter." By H. J. Johnston-Lavis, M.D.

The great disproportion between the displays of volcanic activity in the same volcano at different times, and between the eruptions of different volcanoes, is a subject deserving the most attentive consideration. The violence of a volcanic outburst does not bear any relation to the quantity of material ejected. The union of water with lavas may be compared with the solution of a gas in water; but there is reason to believe that in their deep-seated sources lavas contain little or no water. If igneous matter be extruded through dry strata, the eruption might take place without explosive manifestations. But if igneous matter be extruded through water-bearing beds, a kind of dialysis would take place between the igneous and aqueous masses. In this way the tension of the steam in the fluid rock may at last become so great that a fissure will be formed at the surface and volcanic action will follow.

In this way the violence of a volcanic eruption will be determined by the quantity of water contained in the strata through which the lava passes in its passage to the surface, and by the temperature at which it reaches the surface.

This theory explains the acknowledged sequence of volcanic outbursts of different degrees of violence, and the intervals which occur between them. It also explains the differences between the central and lateral eruptions of a great volcano, and the phenomena attending its extinction.

The structures of the igneous rocks, whether of basic or acid composition, are greatly modified by the presence in them of volatile ingredients.

The succession of events indicated by the structure of Monte Somma and Vesuvius, Roccamonfina, Monte Vulture and Monte Nuovo, show that after a long cessation of volcanic activity we have an extensive production of fragmentary and scoriaceous material, and that this is gradually succeeded by the eruption of lava-streams.

The water and other volatile substances, such as sulphates and chlorides, which are given off abundantly in volcanic eruptions, may act as solvents for the various minerals which constitute lavas.

IV.—GEOLOGICAL SOCIETY OF GLASGOW.

MR. JOHN YOUNG, F.G.S., ON "CONE-IN-CONE" STRUCTURE.

March 12, 1885.—The following is an abstract of the paper read [1] by Mr. John Young, F.G.S., on the remarkable and puzzling structure known as "Cone-in-cone," which has not up till this time been satisfactorily accounted for by any geological observer. Mr. Young stated that this remarkable rock structure is found in certain sedimentary strata belonging to various geological formations, and is chiefly composed of lime, clay, and iron. In the Carboniferous rocks of the West of Scotland it is generally known as a thin stratum, or in flat lenticular masses often closely associated with beds of clay-carbonate of iron which, from the contained fossils, give indications of having been deposited, not in the sea, but under shallow lacustrine conditions. "Cone-in-cone" is composed of a series of vertical cones of varying size, arranged in successive conical concentric layers, one within another, the apices being invariably downwards or to the bottom of the stratum, while the bases of the cones or broad ends are upwards, and in the case of the larger examples terminate on the surface of the bed. The first record of the structure which had come under the author's notice was that by the Rev. David Ure, who, in his history of Rutherglen and East Kilbride, 1793, gave a figure and short description, stating that "cone-in-cone" was found at Mauchlanhole Torrance, Kilbride, and was known to the miners as the "Maggyband." There were also several other notices by subsequent observers, and in these the formation of the structure had been ascribed to the action of various causes, such as chemical precipitation, the action of pressure on concretions in process of forming, and to a kind of crystallisation in the stratum after the deposition of the sediment of which the bed was composed. Mr. Young next pointed out in detail how he had been led during the careful study of a large series of specimens of "cone-in-cone," obtained from various localities of the western Scottish coal-field, to form very different conclusions as to the origin of the structure from those previously advanced. In these specimens are revealed external characters and points of internal structure which apparently had not been recorded, or at all events had been overlooked in all the descriptions which had come under his notice. Briefly stated, the following are the chief conclusions to which he had been led:—1st. That "cone-in-cone" structure is not due to any known chemical precipitation of sediment, subsequent pressure on concretions, or to crystalline action in the stratum after the composing sediment was deposited, but was in all probability formed by the upward escape of gases generated in the deposit whilst the bed was in the process of formation, the gases being derived from the decomposition of the organisms present in the sediment, each ebullition of gas being marked within the cones by a new or successive layer of calcareous sediment. 2nd. That the cone structure originated in the lower portion of the stratum, the cones at first being small and numerous, but as the bed increased in thickness from the upward growth of the cones, many of those first formed became extinct, and were subsequently buried under the spreading layers of the more powerful cones, which continued in action until the structure was brought to a close, apparently through the gradual decrease and final cessation of the gases generated, the cones ending on the surface of the bed in a series of small minor cones, placed within the circumference of the broad upturned ends of the larger cones. 3rd. That there exists between successive calcareous layers of the cones a film of clay of varying thicknesses, which does not seem to have been noticed nor described by previous observers, and that to this thin layer of clay it is due that many of the cone layers now readily separate from each other when the cones are fractured vertically to their axes of growth; also, that there is seen to exist within each cone a central axis or tube, now filled with argillaceous sediment, and into which tube all the separating films of clay converge downwards, being there united to the tube. Through the line of this central axis or tube the calcareous layers of the cones were erupted, the separating films of clay being deposited within the cones from the water in which the stratum was being formed. 4th. That the transverse wrinkling seen on the inner surface of the calcareous layers of the cones appears to be due to a creeping downwards of the plastic sediment of each layer, through gravitation, along the slope of the cones; and, as exemplified in many other plastic substances moving down slopes, their surfaces are often likewise seen to be dragged into a series of transverse corrugations, owing to the surface film of their layers hardening more quickly than that immediately below. In the cones the wrinkling is at right angles to the line of movement of the sediment; and it is clearly evident that this was effected during the formation of their several layers. Had the corrugations been caused at any after period by pressure or any other agency, we should naturally expect to find the separating lines of clay also corrugated; but such is not the case. It is only the upper surfaces of the calcareous layers which are wrinkled, and it is clearly evident that, as the successive films of clay were in every instance deposited on an already wrinkled surface of the calcareous layer, this peculiar character was not of subsequent production. 5th. That the apices of the cones, large and small, are invariably directed downwards in the stratum, their bases or broad ends being upwards, vertical transparent sections of the cones show that there is no truth in the statement made by some observers of "cone-in-cone" that the apices are turned inwards towards each other, with their bases directed to the lower and upper parts of the bed. The whole of the evidence afforded by Scottish specimens clearly shows that the action which went to the formation of this curious structure was exerted from beneath upwards and never downwards, and that towards the close of the growth of the structure the ebullition of gas from below became so feeble as to be unable to do more than to form a group of very small cones at the surface of the stratum, and that small quantities of calcareous sediment were then erupted, layer by layer, until their summits became raised above the general surface level of the bed, after which they became finally extinct. The author, in conclusion, referred to the various localities from which he had obtained "cone-in-cone," and stated that in the Scottish coalfield the structure seems to be always associated with strata in which the contained organisms indicate a freshwater and lacustrine origin for the beds, and that the deposits were therefore probably formed within the areas of wide and shallow lakes.

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[1] From report in *North British Daily Mail*, March 14th, 1885.

CORRESPONDENCE.

THE ENSTATITIC LAVAS OF EYCOTT HILL.

Sir,—With reference to the interesting paper by Prof. Bonney on the Enstatitic Lavas of Eycott Hill, which appeared in the last Number of this Magazine, I venture to make the following remarks.

At the time when Mr. Ward wrote his memoir on the Geology of the northern part of the Lake District, the term andesite was not in use, except as a synonym for andesine felspar. At that period the rocks now termed andesite were called basalt or dolerite.

The determination of rhombic pyroxene in rocks of this class had not then been made, at all events in this country, and the researches of Whitman Cross, Iddings and Teall have been published long since Mr. Ward's death. Although, therefore, enstatite exists in the Eycott Hill Lavas, as now shown by Prof. Bonney, it is not surprising that Mr. Ward did not suspect its presence. This is the less to be wondered at when we consider that he laboured under the great disadvantage of working with a microscope which had no rotating stage or appliances for determining the precise directions of extinction in crystals.

It is, I think, only justice to a departed friend and colleague to offer these explanations. Frank Rutley.

93, Edith Road, West Kensington.

THEORY OF FAULTS.

Sir,—I have referred to Captain Hutton's note on Malta, and quite agree with him that the explanation he gives of downward ending faults may be the right one. What I inquired was, if any geologists knew of *upward*-ending faults in one set of strata?

While I am writing on this subject, will you allow me to add that as some of my friends have expressed disapproval of the tone of my criticisms on Mr. Fisher's paper, I regret that I was led to adopt it. I had no intention of being either personal or offensive.

Doubtless we all have our weaknesses, and if each were to be attacked in a similar manner, harmony would soon be at an end.

Nottingham, *April* 29, 1885. J. F. Blake.

HOMALONOTUS CRASSICAUDA, SANDB., FROM SOUTH DEVON.

Sir,—The remains of *Homalonoti* from British Devonian beds, which were known at the time, having been described by yourself in the Geol. Mag. for November, 1881, and April, 1882, it appears to me worth while to place upon record the occurrence of another species from the New Cut, Lincombe Hill, Torquay.

I have a pygidium in fair preservation, not excessively distorted, but without the shell, which I feel no hesitation in referring to *H. crassicauda*, Sandberger, from the Lower Devonian of the Eifel and Nassau. My specimen is rather larger than the one figured by the Sandbergers.[1] Owing to transverse pressure it has bulged to the left of the axis, giving the latter the appearance of too great width for the species, but this impression is corrected when the pleural portion (somewhat doubled under the bulge) is examined. The right pleural portion is rather imperfect, and a small piece of the flattened extremity is missing; but notwithstanding these defects, the profile closely corresponds with Sandberger's figure (7*a*).

To refigure a well-known species seems unnecessary, but I send the specimen for your examination. A. CHAMPERNOWNE.

I am happy, after examination of the specimen, to be able fully to endorse Mr. Champernowne's determination of the species.—H. W.

METHYLOSIS AND PARAMORPHOSIS.

Sir,—The statement as it appears in my paper in reference to the above is incorrect. *Methylosis* is chemical change from without, while *Paramorphosis* is a molecular re-arrangement without any chemical change. G. HENRY KINAHAN.

April 3rd, 1885.

THE CLASSIFICATION OF THE JURASSIC SYSTEM.

Correction of typographical error in Dr. Blanford's letter.

The Editor regrets that by a most unfortunate oversight on his part, the word CALLOVIAN, in Dr. Blanford's letter (on the third line from the top of p. 240, in the May Number of the MAGAZINE) was by error printed "Calcarian." The passage should read thus:—

"I did not attempt to enter into the classification of minor subdivisions like the Lower Calcareous Grit. But when Mr. Jukes-Browne calls attention to my omission to mention this band, he must have overlooked the circumstance that he has forgotten to notice the far more important *Callovian*, which intervenes between the Oxfordian and the Cornbrash, and which is one of the best known and most widely-spread subdivisions of the Jurassic system."

EDIT. GEOL. MAG.

OBITUARY.

JOHN WATSON LAIDLAY.

JOHN WATSON LAIDLAY, son of John Laidlay, Esq., of Fleetwood, was born at Glasgow on the 27th March, 1808. He commenced his education at a private school at Blackheath, and soon afterwards became a pupil of the illustrious Faraday, with whom he studied practical Chemistry, the enthusiastic pursuit of which had a great influence on all his after life.

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[1] "Die Versteinerungen des Rheinisches Schichten,"—"Systems in Nassau." Atlas, pl. ii. figs. 7, 7*a*, 7*b*.

He studied Hindustani under Dr. Gilchrist in London, where he had the good fortune to meet the late Bishop Heber. When young Laidlay had only attained his 17th year he went out to India in 1825, and entered the employment of his uncles, Messrs. John and Robert Watson & Co., merchants and Indigo planters, Bengal, who were also proprietors of many of the best silk filatures and factories of the East India Company, such as Berhampore, Rampore-Beauleah, Surdah, etc. He was generally in charge of either an indigo factory or a silk filature from 1826 till about 1841, when he spent some time in Berhampore, *i.e.* Moorshedebad, where he made many friends. He married, in 1844, Miss Ellen Johnstone Hope, daughter of William Hope, Esq., of Duddingston, near Edinburgh, and after that resided in Calcutta. His talent for languages was very great, and his love of deciphering inscriptions on the stones of ancient edifices and on coins, and his perseverance in chemical researches, brought him into correspondence with many of the early scientific men connected with Indian affairs, who afterwards became his attached personal friends.

His most numerous literary and scientific communications were published in the Journal of the Bengal Asiatic Society. He was also connected with, and for a short time one of the Secretaries of, the Royal Asiatic Society of Bengal. In the Journal of the former society his name appears in connection with numerous memoirs between the years 1834 and 1849. He originated the "Bibliotheca Indica," a serial publication of native Indian literature, which has proved a most valuable work, and is still continued.[1]

His translation of "The Pilgrimage of Fa Hian" showed great perseverance. In 1839 he went to the Straits Settlements for his health, where he made the acquaintance of Rajah Sir James Brooke.

His services in India extended from 1826 to 1849, when he retired from active life to reside partly in London and at various other places, and finally, in 1854, at Seacliff, near North Berwick, Haddingtonshire, Scotland.

Here his private life was one of constant study and useful work in chemistry, meteorology, archæology, and natural history pursuits. But much learning did not turn his thoughts from a warm interest in the welfare of his family, and now that he is gone, they—more than all others who knew the never-failing charm of his conversation and the goodness of his large and generous heart—can realize how great is their loss.

At Seacliff, among other matters, he investigated the supposed rise of the East Coast of Scotland since Roman times, and showed, by means of the discovery of a prehistoric habitation near Seacliff, North Berwick, Haddingtonshire, on a rock only 23 feet above high-water mark, that, had the land been lowered, this habitation, with all its remains, must have been entirely swept away. See note in the GEOL. MAG. Vol. VII. 1870, pp. 270, 271.[2]

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[1] For this work Mr. Laidlay succeeded in obtaining a grant in aid from the Government.

[2] For a fuller account of this interesting discovery see the Trans. of the Scottish Archæological Society, 1870–71.

Mr. Laidlay presented a collection of shells to the British Museum, and was also a donor of coins and other objects of archæological interest to the Nation. He died March 8th, 1885, and leaves a family of five sons and two daughters.

PROFESSOR RUDOLF WILHELM DUNKER.

We regret to record the loss of this veteran German geologist, who died, after a brief illness, on March 13th, 1885, at Marburg, Hesse Cassel.

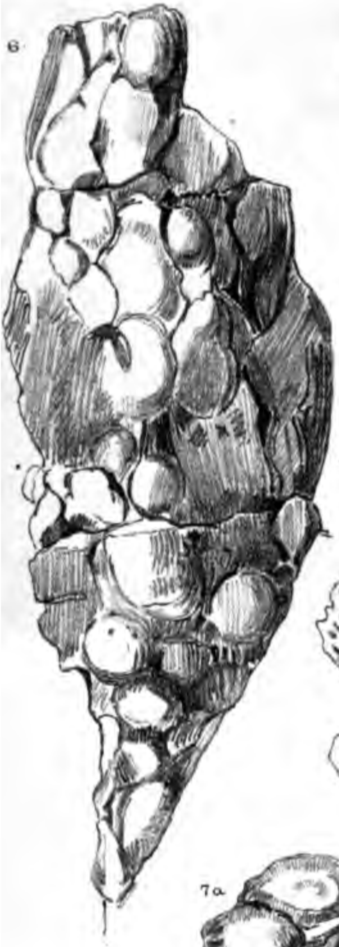
Wilhelm Dunker was born at Eschwege, on 21st February, 1809, and after the usual studies at the Gymnasia of Cassel and Rinteln, he entered upon a course of practical mining at Oberkirchen, etc. His first scientific work was the investigation of the Wealden formation, a task not before attempted in North Germany. Having passed his examination in practical mining, he entered the University of Göttingen in 1830, where he studied under Blumenbach and other famous professors.

Having completed his education, he returned to Oberkirchen in 1837, and resumed his researches in the Wealden, etc. (see vol. i. Studien Göttingischen Vereins S. 291 ff.). In 1838 he graduated in Jena. In 1839 he accepted the lectureship of Mineralogy and Geology in the Polytechnic School of Cassel. In April, 1840, Prof. Dunker was married to his cousin, Elise Sommer. At Cassel he prepared his Wealden Memoir for publication (drawing the plates with his own hands), and being assisted by Hermann von Meyer, who described the Reptilian remains. Whilst engaged on this work he conceived the idea of issuing a palæontological journal, which he soon after commenced with H. von Meyer (known as the *Palæontographica*), Theodor Fischer of Cassel having undertaken its publication. This work has now been in constant issue for 35 years, and contains a vast number of valuable memoirs.

In 1854 Dunker was chosen Professor and Director of the Mineralogical Institute in Marburg, and in 1880 he was elected to the Chair of Mineralogy in that University, where he resided until his death. He was the author of about 70 memoirs, chiefly upon the Mollusca, of which also he possessed a fine collection. He died at the age of seventy-six years, universally regretted by all his friends and fellow-professors.

MISCELLANEOUS.

Dr. Franz Ritter von Hauer, Director of the Geological Survey of Austria, with which he has been connected since its earliest institution, has been appointed by the Emperor of Austria to the post of Intendant of the Imperial Natural History Museum of Vienna, lately vacant by the death of Dr. Ferdinand von Hochstetter. The colleagues of Dr. von Hauer presented him with a sympathetic address of regret at his quitting the Survey and of congratulation on his appointment, and they have resolved to have a portrait of him painted by a distinguished artist, which is to be placed in the Museum of the Survey at Vienna.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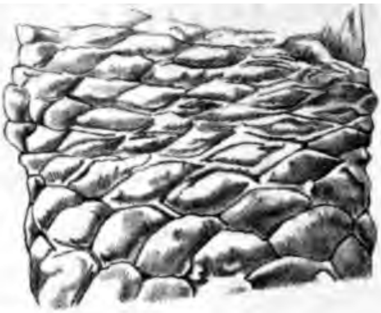
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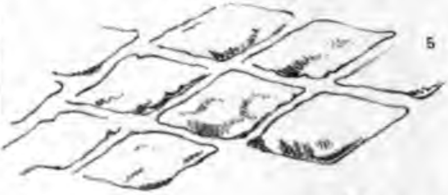
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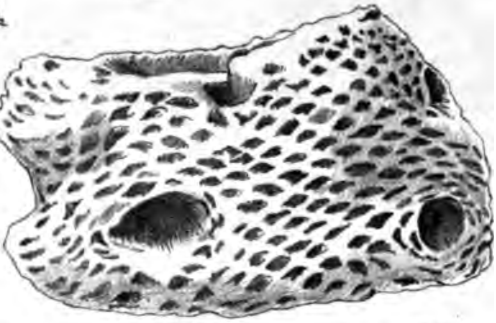
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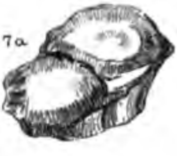
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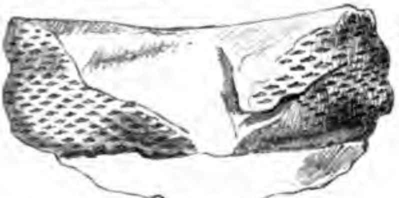
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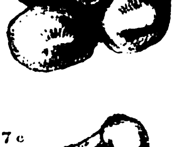
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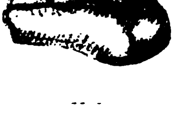
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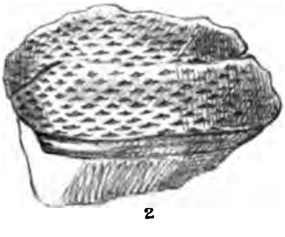
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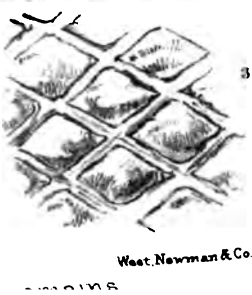
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THE

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NEW SERIES. DECADE III. VOL. II.

No. VII.—JULY, 1885.

ORIGINAL ARTICLES.

I.—NOTES ON SOME MESOZOIC PLANT-REMAINS FROM SOUTH AUSTRALIA.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S., etc.

(PLATE VII.)

THOSE who have attempted a geological exploration of a new country can best appreciate the difficulties which must be overcome by the geologist, and the value of every scrap of fossil evidence met with, however fragmentary, which may serve as an indication of the probable horizon of the strata around him.

Such evidence comes to the geologist in the field, like the drift-wood to Columbus in the Atlantic, as an earnest of land-ahead, in the midst of an ocean of doubt and difficulty.

Mr. Henry Y. Lyell Brown, F.G.S., the Government-Geologist for South Australia, to whose reports we have already directed attention in these pages,[1] has, with his small Staff, a vast and most arduous task to perform in mapping geologically, even in the most superficial manner, this great country whose Southern area contains upwards of 380,000 square miles, whilst the Northern territory, annexed in 1861, gave no less than 523,620 square miles additional! stretching from sea to sea, and only touched upon heretofore by a geological reconnaissance of the Palæozoic area near Adelaide in 1859,[2] and by a second Report on the same in 1862.[3]

As always happens in all such undertakings the Government Geologist is expected to be a second "Moses in the Wilderness," and, like the great lawgiver, it is assumed he needs only to touch the stony rock, and the waters will gush forth! It is to be regretted that the "Divining-rod" is no longer potent for such objects as mines and springs, for in a new country, where both are so greatly in demand, the geologist, who should possess this powerful instrument, might fairly expect, if he proved successful, to be canonized as a saint by his fellow-colonists, or, if he failed, to be lynched for an impostor! In so vast an area as we have indicated, every farmer, land-surveyor, explorer, and prospector, should be laid under contribution to bring information to the Government-Geologist as to the nature of the districts visited. Sometimes an intelligent Squatter or Miner is thus enabled to render most valuable service to the Colonial Geologist.

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[1] See Review of Report by Government Geologist, GEOL. MAG. 1884, p. 29. See also Notes on Mollusca from S. Australia, op. cit. p. 339, Pl. XI., and on Trilobites, p. 342. Also Annual Report to 31 Dec. 1883, by H. Y. L. Brown, op. cit. 1885, pp. 41-43.

[2] See A. R. C. Selwyn's Report on Palæozoic area, Parliamentary Papers for S. Australia, 1859, No. 20.

[3] See E. H. Hargrave's Report on same area, Parliamentary Papers, No. 96, 1864.

Having lately received from Mr. H. Y. Lyell Brown some specimens brought in by explorers, from Mount Babbage, Mount Adams, from Cutaway Hill, and from Mount Gammon, Aroona, and other localities in South Australia, I propose to give a short account of some of them here.

Fossils from Mount Babbage.—According to Hargrave's Map of South Australia, published in 1864, Mount Babbage appears to be situate at the head of Hamilton Creek, which runs into the northern portion of Lake Frome, and is a considerable distance to the south-east of Blanche Water; being 30° S. lat. and 140° E. long.

The fossils from this locality consist of plant-remains almost entirely converted into a pure quartzite, only superficially stained with iron and having slight traces of carbonaceous matter remaining.

1.—The most interesting of these is the fragment of a small stem (Plate VII. Figs. 1, 2), the internal structure of which has disappeared and the cavity has been occupied by quartzite. On the exterior a thin carbonaceous crust, most of which is now removed, renders more prominent a fine net-work of extremely minute compressed elliptical or lozenge-shaped scars, indicating the bases of the petioles; 6 of these scars measure only 20 millimetres in breadth, and 9 scars occupy the same space in height. The diameter of the stem is 5 centimetres.

The fragment is, I have no doubt, a portion of the stem of a plant which has been closely covered with leaves, such as we find in some Monocotyledonous plants like the "Black-Boys" and "Grass-trees" (*Xanthorrhœa* and *Kingia*) of Australia, or perhaps still more like those Cycadeæ whose stems are covered with the permanent bases of the leaves. I have compared this specimen with the figures of *Mantellia inclusa*, Carr., given by Mr. Carruthers in his Memoir on "Fossil Cycadean Stems from the Secondary Rocks of Britain" (Trans. Linn. Soc. Lond. vol. xxvi. 1868, p. 703, tab. lxiii. figs. 2 3), and have reproduced his fig. 3 on our Plate (Pl. VII. Fig. 4) for reference.

Of course but little can be said in the way of detailed description of so fragmentary a fossil remain; nevertheless from the comparison I have made, I am inclined to consider this fossil to belong to the *Cycadeæ* and perhaps to the genus *Mantellia*. If it be desirable, for convenience of reference, to give it a specific name, I would suggest *M. Babbagensis* as its trivial name, after the locality from whence it was derived.

This represents, so far as I am aware, the smallest Cycadean-like stem hitherto recorded from any locality.

2.—The next specimen to which I wish to call attention is from the same locality[1] as the last, and is preserved in an exactly similar matrix of quartzite. (See Plate VII. Fig. 6.)

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[1] Some of the specimens are labelled "Mt. Adams." Is Mt. Adams *synonymous with Mt. Babbage?* This is a point which should be cleared up.

I concluded, at first sight, that I had before me a badly-preserved specimen of *Clathraria* or *Bucklandia*, agreeing closely in aspect and mineral condition with Mantell's specimens of this Cycad from the Wealden of Tilgate Forest.

In this interpretation, I regret to say, I have not the support of my colleague, Mr. William Carruthers, F.R.S., of the Botanical Department, whose Memoir on the Fossil Cycadeæ I have already quoted. Mr. Carruthers is of opinion that the fragment of silicified wood does not represent a part of the surface of a Cycadean stem covered with more or less rhomboidal scars arranged in close proximity to each other and in a quincuncial matter, but that we are looking at a piece of fossil wood which has been largely occupied by *Teredinæ*, and that the appearance of rhomboidal leaf-scars (see Plate VII. Figs. 6, and *7a, b, c*) is really caused by a more or less compacted mass of the tubes of Teredo, the extremities of which have left the rounded protuberances observed in the fossil. There is certainly an absence of any clear quincuncial arrangement of the leaf-scars (a character clearly observable in Fig. 1 of our Plate), and this is a point upon which Mr. Carruthers very strongly insists. There is of course an alternative course open, namely, to suggest that it is a Cycadean stem bored into by Teredoes; but if we admit the *Teredo*-theory, there is no evidence as to the nature of the wood itself into which they had bored, that being (save for the carbonaceous crust) replaced by quartzite.

In a case of this kind it seems highly desirable to call attention to these remains, although so very fragmentary, in order that further search may be made, and other and better-preserved specimens obtained.

There is another specimen in exactly similar lithological condition to those from Mt. Babbage, marked Mt. Adams, but it does not throw any additional light upon the exact botanical nature of these fossils.

3.—A block of quartzite or sandstone, covered upon one side with impressions of strap-like leaves and slender stalks of some vegetable, and an obscure hollow impression which may possibly have contained a fruit, suggest the abundant presence of plant remains. These are marked "Cutaway Hills, Leigh's Creek." Similar casts of plant-fragments occur in the same locality in a white compact fine-grained siliceous matrix, which seems largely made up of impressions of plants, although the carbonaceous matter has been removed. Neither affords sufficient evidence for exact determination.

Leigh's Creek is marked upon Mr. Hy. Y. L. Brown's Map of South Australia as a Southern branch of the Froome River, running out of one of the arms of Lake Eyre (138° East Long., and about 30° S. Lat.); but Cutaway Hills are not marked on the map.

4.—Another specimen, labelled "Mount Adams,"[1] consists of a very similar quartzite to the preceding, but less saccharoid, on one surface of which is seen the impression of a palmate leaf, half of which only

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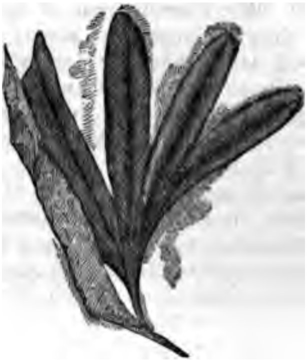
[1] Is Mount Adams the same place as Mount Babbage?

is preserved, cut down to near the base (see woodcut), the segments spreading on either side of the central one, and being three in number on the side preserved. The digitations are linear, with a thick mid-rib passing up the centre of each segment.



Leaf from Mount Adams.

The cuneate base runs down into a slender petiole. By its side are the fragments of two leaves or leaflets, which agree in having a strong central rib and have a close resemblance to fragments of the leaflets of the living genus *Cycas*, but if they are connected with the palmate leaf, we must look for other affinities, for that leaf would not fit into any form of leaf known among the *Cycadeæ*.

The form of the palmate leaf at once suggests the leaf of a *Salisburia*, but the single median rib in each segment, though found in many *Coniferæ*, as for instance in *Podocarpus*, is very different from the numerous slender dichotomous veins found in *Salisburia*, and in the fossil forms which have been referred to this genus.

We do not venture to suggest, on the materials before us, any definite position for this fossil.[1]

Mount Babbage[2] and Leigh's Creek are about 130 miles apart; both localities are mapped as Mesozoic by Mr. Brown. Probably the specimens here noticed may be of Lower Cretaceous age;[3] but more evidence is wanting before a decided judgment can be pronounced upon them as to their geological age, and more specimens are needed to determine their affinities.

EXPLANATION OF PLATE VII.

Fig. 1.	Portion of cast of stem of *Mantellia? Babbagensis*, H. Woodw. (nat. size), from Mount Babbage, South Australia.
,, 2.	The same, end view.
,, 3.	Some bracts of Cycad enlarged.
,, 4.	*Mantellia inclusa* (half nat. size), Carruthers. Trans. Linn. Soc. vol. xxvi. tab. 63, fig. 3, p. 703. Original from Potton Sands, Cambridgeshire. (York Museum.)
,, 5.	Bracts of *Mantellia intermedia* (half nat. size).

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[1] Twenty-two specimens sent in from Gammon range are inorganic concretions. Some have been cut open with the circular saw, but they yield no information to repay the investigator. The matrix looks like a Palæozoic rock.

[2] And ? Mount Adams.

[3] The late Mr. Charles Moore, F.G.S., in his paper on Australian Mesozoic Geology and Palæontology (Quart. Journ. Geol. Soc. 1870, vol. xxvi. pp. 226–261. *pl. x.–xviii.*), speaks of Cretaceous beds, but his paper does not aid our present inquiry.

Fig. 6. Supposed Cycadean (?) stem, Mt. Babbage (or Mt. Adams ?). Cast of portion of fossil wood (replaced by quartzite) bored by *Teredo* (Carruthers,) (nat. size).

„ 7, *a*, *b*. Supposed ends of permanent bases of leaves from stem (Fig. 6), considered by Mr. Carruthers to be casts of ends of *Teredo*-tubes.

„ 7*c*. Profile of some of the supposed bases of leaves detached from stem, like Fig. 6.

„ 8. Part of stem of *Bucklandia Milleriana*, Carr. (*op. cit.* tab. lv. fig. 1, p. 687), original from the Coral Rag of Brora, Sutherlandshire (half nat. size).

II.—The Classification of Stratified Rocks.

By A. J. Jukes-Browne, B.A., F.G.S.

MANY attempts to revive and improve the classification of our rock-groups have been made from time to time, and the International Geological Congress will doubtless make a further effort in the same direction.

Systematists seem now generally to agree in allowing four ranks to the divisions of the geological series :—

1. Such divisions as Palæozoic and Neozoic, or Primary, Secondary, and Tertiary.
2. The subordinate divisions which are generally termed systems, such as Silurian, Cretaceous, etc.
3. The subdivision of these systems into series usually called Upper, Middle and Lower, but sometimes by special names.
4. The smaller local groups or stages into which the subdivisions naturally fall, such as Oxford Clay, Millstone Grit, etc.

But when they come to rank the recognized groups under these heads, and to decide upon the number of systems which should be admitted into the geological scale, then there is much difference of opinion.

The latest attempt to improve our classification is by Dr. Blanford, in the Geological Magazine for 1884, p. 318, and with his preliminary remarks I think all geologists must cordially agree. He points out that if our classification is to have anything like universal application, the first essential condition is that the major divisions should be of nearly equal value ; that if systems are determined by the thickness of strata or by the physical breaks which occur in any one country, they cannot be of equal value : consequently the logical conclusion is that systems must be established on a palæontological basis, and on the evidence of change in the marine faunas.

To concede that unconformities are geological accidents and of little use in classification is a step in the right direction.[1] If they were always taken as the limits of systems, several different classifications would be required for the British strata alone. A single instance will suffice to prove this :—In Scotland, and probably in Wales also, there is an upward passage from Silurian into Lower Old Red Sandstone, then an unconformity and a passage from Upper O.R.S. into Carboniferous ; here therefore there are only two systems if the break is to be the limit ; but let us pass into Devonshire, and we find no break, but a continuous series divisible into three groups with distinct faunas, and each entitled to rank as a system.

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[1] Vide Lapworth, Geol. Mag. Dec. II. Vol. VI. p. 10.

As in this instance, so in others, the breaks in the succession of one district are certain to be filled up elsewhere by transitional beds, and as these may contain a fauna of high systematic value, we must always be prepared for the possible intercalation of another system between any two groups that are divided by a decided unconformity.

Systems must therefore be founded on the evidence of fossils in some area where a continuous succession of marine deposits is found; a system may perhaps be defined as a series of strata deposited during the continuance of a certain set of generic forms in any given part of the world. Such a definition will probably be found sufficiently elastic, and yet definite enough to secure an approximate equality of value for the several systems. The proportion of special characteristic genera must be variable, but probably it is about one-third of the total number of genera in the faunas of the Palæozoic and Mesozoic systems.

It must be conceded at once that systems founded on the differences in successive faunas will not include anything like equal thicknesses of rock. If, as appears most probable, the differentiation of species and the development of higher forms has progressed in a constantly increasing ratio, it is clear that the time-value of systems based on such systems will become less and less as we approach modern times. It is certainly a fact that the same forms of life extend through a much greater thickness of rock in the earlier than in later geological times, and they also appear to have had a wider geographical distribution. There is no reason for supposing that the production of rocks went on more rapidly (at any rate during later Palæozoic periods) than at the present time; limestones must always have been of slow and gradual growth, and yet the persistence of species through the Carboniferous Limestone Series is truly remarkable, while the limestones of the Jurassic and Cretaceous systems (though much less thick) are divisible into numerous zones, each characterized by species which do not occur in the next. The changes in the forms of life inhabiting any marine area being thus more rapid in later geological times, an equal amount of change would naturally be accomplished in less time, and consequently if systems are to be measured by palæontological differences, the newer systems must include less thickness of rock.

But even when allowance is made for this, it is quite impossible to regard the divisions of Tertiary time introduced by Sir Charles Lyell as being of the same relative importance as the systems of older date with which they are usually ranked. This feeling has been expressed by Dr. Blanford, who notices the proposal of certain Swiss and German geologists to make two Tertiary systems,—an Eocene (comprising the Oligocene) and a Neogene (comprising the later groups). Dr. Blanford, however, thinks that there is "so little probability of this classification being adopted, that the only practicable suggestion appears to be to unite the Oligocene with the Miocene, and to include the Pleistocene, which has no claim to recognition as a separate system, in the Pliocene." He thus constructs three systems under the names of Eocene, Miocene, and Pliocene.

I doubt, however, whether this suggestion is altogether commendable. The fact is that if marine invertebrata are taken as the standard of measurement, there is only one Tertiary system, and in that we are still living, for very few invertebrate genera have become extinct since Eocene times. But if the vertebrates, both marine and terrestrial, are taken into consideration, they afford grounds for making more than one system, though I doubt whether the facts would sanction three as Dr. Blanford proposes.

I agree with those who would limit the number to two, though the nomenclature proposed on the Continent is not likely to be adopted. It appears to me that the existent names may be conveniently retained without alteration or abstraction to represent the major groups or series of the Tertiary systems, and that we have only to find suitable names for the two systems into which they naturally fall. British geologists would naturally prefer names taken from their own country, and in this case it does not seem difficult to provide such names. Hampshire and the Isle of Wight affording the most complete section of the Eocene and Oligocene, *Hantonian* becomes an appropriate name for the system they would constitute. In Britain the Falunian Miocene is absent, and we have only representatives of the Pliocene and Pleistocene; but the three may be merged into a second system for which the name *Icenian* may be revived,[1] a name derived from the British tribe of *Iceni* who inhabited the eastern districts where the typical deposits of these groups are found. For this plan I claim the merit of its not disarranging the existing nomenclature, while it will prevent students from acquiring an exaggerated idea of the geological importance of the Lyellian groups.

The accompanying table will show what systems appear to me to be of nearly equivalent value on the principles above indicated, and I may state that it has been drawn up for the purposes of a volume on Historical Geology now in course of preparation. I wish, however, to ascertain whether the proposals it contains are likely to meet with general approval, and shall therefore welcome criticism from the readers of the GEOLOGICAL MAGAZINE. Those who teach our Science or prepare manuals for teaching purposes necessarily feel the importance of having a consistent and well-proportioned tabular view of the succession of strata, and yet they hesitate to import new views and terms into their lectures and treatises because they are expected to give only the accepted results of geological study.

A few remarks on this Table are necessary. In the first place, I have avoided indicating the limits of the largest divisions or eras of geological time, since there is so much difference of opinion as to the precise boundary-line between the Palæozoic and Mesozoic eras. I must strongly protest against the tripartite division of everything which Dr. Blanford recommends, and especially against the artificial plan of allowing only three systems to each great era of time. Such a plan is certain to give rise to erroneous impressions, and strikes me as an application of mathematics to geology which is not likely to yield useful results. What would Historians think of an attempt to divide English History into three unequal eras, each subdivided into three unequal periods, with every reign or chapter treated in three parts? Is there such magic in the number three that a tripartite division of the geological record is calculated to afford us a clearer conception of its contents? · Even the three cardinal divisions are hardly defensible on palæontological grounds, though they are convenient for some purposes. A primary division into Palæozoic and Neozoic, with five or six systems in each, would be far more scientific.

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[1] This name was proposed by Dr. S. P. Woodward as a synonym for Pliocene in his Manual of the Mollusca, 1851.

I adopt Prof. Lapworth's name *Ordovician* for the system of the second fauna, as the only practicable way out of the Sedgwick and Murchison controversy, and certainly regard the Cambrian, Ordovician, and Silurian as systems equivalent in palæontological value to Devonian and Carboniferous. I think, however, the nomenclature of the Ordovician series stands in need of improvement; Lower, Middle, and Upper would, perhaps, be better than retaining the old names of Arenig, Llandeilo, and Bala for the primary divisions.

In the case of the Silurian system a different nomenclature must be adopted because of the confusion which would arise from the use of 'Lower' Silurian. Prof. Lapworth's name of *Valentian* may be adopted for the Llandoveries, *Salopian* may do for the Middle series, but *Downtonian*, which has been used for the Upper series, is so eminently unclassical that it will hardly pass muster. A new name seems, therefore, to be required, and I venture to propose *Clunian* from Clun Forest, in Shropshire, where these uppermost Silurians and the Tilestones are largely developed (see Sheet 30 of the Horizontal Sections of the Geological Survey, and Jukes' Manual of Geology, 2nd ed. p. 481). For the Devonian system the marine series must clearly be adopted as the type, but it is possible that some of the Upper Devonian and Upper O.R.S. may have to be transferred to the Carboniferous system.

As regards the Carboniferous system, I find there are weighty objections to Prof. Hull's proposals to create a Middle series. The Yoredales are so essentially a part of the Carboniferous Limestone series, that they ought not to be separated from it, while the Millstone Grit is similarly linked to the Coal-measures. Moreover, Prof. Green has shown that there is a well-marked line at the base of the Millstone Grit, so that the old division of the system into an Upper and Lower appears more true to nature than a triple series would be.

Whether the Dyas (Permian) is entitled to rank as a separate system is very doubtful. The conditions under which it was formed appear to have enabled a portion of the Carboniferous fauna to perpetuate their existence in the European area while Mesozoic life was being rapidly developed elsewhere. I doubt, therefore, whether we can in this instance take Palæontology as a guide, and think it

SYSTEMS.	PRIMARY DIVISIONS.	GROUPS OR STAGES.
ICENIAN.	PLEISTOCENE.	Recent deposits. Raised beaches and Valley gravels. Glacial deposits.
	PLIOCENE.	Forest Bed, Norwich Crag, Red Crag, and White Crag.
	MIOCENE.	None in Britain.
HANTONIAN.	OLIGOCENE.	Upper (wanting in Britain). Hempstead and Bembridge Beds. Lower Headon Beds.
	EOCENE.	Bagshot and Barton beds. London Clay. Lower London Tertiaries.
CRETACEOUS.	UPPER.	Chalk Upper. Middle. Lower. Upper Greensand and Gault.
	LOWER.	Vectian or Lower Greensand. Wealden and Neocomian.
JURASSIC.	UPPER.	Purbeck and Portland beds. Kimmeridge Clay. Corallian and Oxford Clay.
	MIDDLE.	Great Oolite series. Inferior Oolite series.
	LOWER.	Upper Lias. Marlstone and Sands. Lower Lias and Rhætic?
TRIASSIC.	KEUPER.	Marls, Sandstones, and Conglomerate.
	MUSCHELKALK.	Absent in Britain.
	BUNTER.	U Sandstone. Pebble Beds. L. Sandstone.
——	DYAS.	Magnesian Limestone and St. Bees Sandstone. Marl Slates and Penrith Sandstone.
CARBONIFEROUS.	UPPER.	Coal-measures Upper. Middle. Lower. Millstone Grit.
	LOWER.	Carboniferous Limestone Series or Bernician. Tuedian and Upper O R.S.
DEVONIAN.	UPPER.	Barnstaple, Marwood and Pickwell Down Beds.
	MIDDLE.	Mortehoe Slates and Ilfracombe Beds.
	LOWER.	Hangman Grits and Lynton Beds.
SILURIAN.	CLUNIAN.	Tilestones and Downton Sandstone. U. Ludlow and Aymestry Limestone.
	SALOPIAN.	Lower Ludlow Wenlock Limestone, shale, and Woolhope Limestone.
	VALENTIAN.	Tarannon Shales. May Hill Sandstone. Lower Llandovery.
ORDOVICIAN.	BALA ROCKS.	Hirnant Beds. Ashgill Shales, Bala and Coniston Limestones, Slates and Sandstones.
	LLANDEILO FLAGS.	Flags with *O. Buchii*. Shales with *As. tyrannus*. Llanvirn series.
	ARENIG GRITS.	Upper and Lower grits.
		Tremadoc slates.
CAMBRIAN.	UPPER.	Lingula flags Dolgelly group. Ffestiniog group. Maentwrog group.
	LOWER.	Menevian (Upper and Lower). Harlech group (Upper and Lower).
ARCHÆAN, OR, PRE-CAMBRIAN.		

best for the present to class the Dyas, neither under Palæozoic nor Neozoic, but as a period of transition between these two great eras in the development of life.

I have kept the old divisions of the Trias, though I admit the desirability of eventually abandoning them, and of adopting the marine sequence of the Alps as a type. By that time, perhaps, a better name for the system may be found, and the Rhætic may then be included in it. In Britain the Penarth Beds link themselves rather to the Lias than to the Trias, but this may be because our Trias is not marine.

In the Cretaceous system I have degraded *Neocomian* to its proper subsidiary rank as a stage of the Lower division. The use of the term for the whole of this lower series is an unwarrantable and unnecessary innovation, which can only result in confusion. The true Neocomian of Southern France seems to be the marine representative of our Wealden, and no part of it corresponds to our Lower Greensand. This last name and its correlative, Upper Greensand, are certainly doomed to abolition; the Lower Greensand can be studied so well in the Isle of Wight, where the labours of Edward Forbes added so largely to our knowledge of it, that no name can be more appropriate than *Vectian*; and I regard the introduction of a new name as preferable to the adoption of the French names *Aptien* and *Urgonien.* The Gault and Upper Greensand require further investigation, so I leave them for the present.

My reasons for admitting only two systems in the Tertiary, and for giving new names to these, have already been explained. Quaternary, Post-Tertiary, and Post-Pliocene I regard as unnecessary and unscientific terms.

III.—ON THE GEOLOGICAL HISTORY OF THE CORNISH SERPENTINOUS ROCKS.

By J. H. COLLINS, F.G.S.

1.—THE LIZARD SERPENTINES.

THE remarks by Professor Bonney on Dr. Sterry Hunt's recently published "Geological History of Serpentines," which appeared in the September Number of the GEOLOGICAL MAGAZINE, open up a very wide question—a question which broadly divides the non-chemical from the chemical geologists and petrologists. Dr. Sterry Hunt is well able to take care of himself in this discussion, and certainly I have no present desire to take part in it except so far as it relates to the Cornish areas, some of which are therein referred to. These I have especially studied, and with respect to them I feel bound to say that I find myself able entirely to agree with the conclusions of Dr. Sterry Hunt.

One of the regions in question, that of Porthalla, has also been referred to by Mr. Alexander Somervail, in a letter which appeared in the GEOLOGICAL MAGAZINE, 1884, Dec. III. Vol. I. p. 479. This letter, however, brings forward neither new facts nor new arguments —it merely sets my conclusions (see my paper read before the

Geological Society of London)[1] aside by a repetition of the dogmatic assertion that the serpentine here "has forced itself through and among the schists," and "actually infuses itself into their composition at and near their junctions, so as to form a kind of transition between the two rocks of opposite origin, which Mr. Collins has very evidently mistaken for serpentine in a less altered form, thus seeming to favour his mistaken conclusion of the serpentine being only an altered slate."

I may here remark that the expression "the serpentine being only an altered slate" does not quite accurately convey my meaning, although, of course, I find no fault with Mr. Somervail for using it. What I believe is, not that "the slate" has been altered into serpentine, but that, of an originally differing series of conformable bedded rocks, some beds have been converted into that peculiar variety of hornblende schist which characterizes the locality, others have been converted into true serpentine, and others again into a rock of intermediate character. In fact I consider that we have here the final results of a long series of processes of "selective metamorphism," the same agents acting for the same times on dissimilar masses, and so giving rise to dissimilar products. Moreover, as there were originally transition beds of the original strata, so now there are transition results in all stages, so affording complete series of passage specimens, not "apparent" merely, but veritable and real. In all these cases it seems to me likely that a hornblendic mineral has been first formed, and that the conversion of this into serpentine is the final change.

It is, moreover, obvious that such reactions might take place, under suitable circumstances, so as to change a rock mass into serpentine quite irrespective of its mode of origin, whether igneous or aqueous, and one has not to go outside the borders of Cornwall, perhaps not outside the borders of the Lizard district, to find examples of both classes of rocks which have undergone this change.

Speaking of the serpentine more especially of Coverack, Professor Bonney says, in his recent communication (Geol. Mag. 1884, p. 409): "If there be in Nature *any indications from which we can assert the intrusive character of any igneous rock whatever, we have these indications in the case of the Lizard serpentine and the associated sedimentary series.*"

I by no means deny that this description is fairly enough applicable to the Coverack serpentine, and I do not dispute that this particular serpentine has resulted from the alteration of an igneous intrusive rock, as stated by the Professor. Still, I agree with Dr. Sterry Hunt in thinking that such appearances (of intrusion) *may* very often, if not usually, be "explained by subsequent movements of the strata in which the serpentines are included" (*op. cit. conclusion*).

Moreover, I assert that the serpentinous beds of Porthalla, Mullion, and the greater part of the Lizard district do not possess the unmistakeable indications alluded to, but, on the contrary, they have the closest possible inter-relations with the hornblende-schists of the same localities, both stratigraphically and chemically.

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[1] Quart. Journ. Geol. Soc. 1884, vol. xl. pp. 458-471.

Prof. Bonney has expressed the opinion—and I understand Mr. Somervail to endorse this—that the existence of intrusive serpentine in other parts of the Lizard District would be *prima facie* ground for believing in a like origin for that of Porthalla; and this, in the absence of positive evidence to the contrary, I should be disposed to admit. The main object of my paper on the Porthalla rocks (which are entirely different from those of Coverack and Cadgwith) was to afford such positive evidence; and, speaking as a chemist, I must reiterate my belief that it is impossible for any one to explain satisfactorily the origin of the specimens I exhibited to the Geological Society in illustration of my recent paper, and especially the specimens marked C and D, without admitting that serpentine has been formed *within the substance of the hornblendic stratified rock.* Not only does this latter entirely enclose portions of chemically pure serpentine, but also there are fragments of intermediate composition of every degree visible, some of which I have isolated and analysed. It seems to me, therefore, we must either admit that these have been formed within the substance of the schist, or that they existed as serpentine previous to its formation, and now represent a kind of breccia. I have no doubt that the first hypothesis is the true one.

Prof. Bonney and others have appealed to the evidence of the microscope in disproof of my conclusions. I have not, however, arrived at these conclusions without much use of that instrument, and I still assert that the evidence—fairly interpreted—is in my favour. The massive serpentine of Porthalla does not present that reticulated structure which has been regarded as the result of the alteration of olivine rocks. But even if it did, this would be no proof of its igneous origin, inasmuch as the essentially Neptunian origin of many olivines has been quite conclusively shown by Dr. Sterry Hunt and others.

The transformation of one chemical substance into another by the withdrawal of some of its components and the substitution of others is a process which is continually going on in all rocks which are so situated that natural waters are able to percolate through them. It is well known too that all rocks are—some more, some less—permeable to water. To chemical geologists such changes are matters of every-day observation; yet, for expressing an opinion that such a transformation has taken place, in the case of the Cornish serpentines, my views have been characterized as something like the "transmutation" of the old alchemists (see discussion on my paper.[1])

Such changes have been fully described and traced in the case of serpentine by Dr. Heddle, Dr. Sterry Hunt, and many other writers of repute. Dr. Sterry Hunt states as the result of his own experiments that "whenever the comparatively soluble silicates of alkalies or of lime are brought into contact with solutions like sea-water—holding magnesia sulphate or chloride—double decomposition takes place with the separation of a very insoluble gelatinous silicate of magnesia, and further that precipitated silicate of lime is decomposed by digestion with such magnesian solutions, its lime becoming par-

[1] Abstract of Proceedings Geological Society of London, Q. J. G. S. p. 472, 1884.

tially or wholly replaced by magnesia" (Geol. Hist. of Serpentines, 1873, p. 169). These experiments date from 1860, their accuracy has never, I believe, been disputed, and the hypothesis, as regards the formation of serpentine, "has been adopted by Delesse, Gümbel, Credner, Favre, Dieulefait, and Stapf" (*ibid.* p. 206).

As regards the removal of alumina in solution, which has been thought to be a difficulty, Dr. Heddle says, "Silicate of alumina can be decomposed by chloride of magnesium or sulphate of magnesium, silicate of magnesia being formed" (quoted in Min. Mag. vol. iii. p. 139). I myself have found that sea-water, aided by heat and pressure dissolves out not only lime (when present) and alkalies, but also alumina and a little silica from all varieties of felspar.

The late David Forbes was a firm believer in the dolomitic origin of much of the Lizard serpentine. The following are two of his analyses of serpentinous rocks from a Cornish locality as given by Capt. Marshall-Hall (Min. Mag. vol. iii. p. 213):—

	Dolomitic.		Serpentinic.
Silica	3·43	...	39·48
Oxides of iron and alumina	1·15	...	1·65
Lime	13·37	...	24·14
Magnesia	20·12	...	18·16
Carbonic acid	49·04	...	13·83
Water	12·91	...	4·56
	100·02		101·82

Of course these substances are much farther removed from true serpentines than those ordinarily met with in the Lizard district. The changes indeed are evidently far from complete; they may nevertheless serve in some degree to indicate one mode in which such transformations have been brought about.

The origin of the Porthalla serpentine, as well as that of Mullion and the greater part of the Lizard district has been, I believe, brought about pretty much as follows:—

A series of beds of ancient stratified rocks—including siliceous limestones and dolomites of varying composition and texture, some therefore, more permeable than others—has been contorted and compressed during many ages. At some periods during the long series of changes, they have been subject to the action of magnesian chlorides in solution, at an elevated temperature, and under considerable pressure; submergence in the waters of the sea to a considerable depth would suffice to give all these conditions.

In this way from the more permeable beds silicates of alkalies and of lime together with alumina might be carried away in solution and silicates of magnesia deposited—the oxides of iron present remaining unchanged or nearly so. The less permeable beds perhaps have suffered internal changes of a less complete character—the ultimate chemical composition here may perhaps be pretty much as it was originally, but the components have been rearranged so as to give rise to the peculiar hornblendic and felspathic constituent minerals now present. Of course if there had been any veins of igneous rock previously injected before these chemical agencies had got to work, these too if they were susceptible of conversion into serpentine might be so converted, and we should then have *intrusive* serpentine as well as interbedded serpentine, not merely in neighbouring localities, but actually in the same locality.

Assuming the intrusive nature of the Coverack rock, it may be that such has been its origin, and such has been certainly the origin of the serpentinous rocks of Clicker Tor, and other localities, to be hereafter referred to. I must here repeat, however, that I have been unable to find any evidence of the existence of intrusive serpentine rock at Porthalla, Mullion, or Kynance.

IV.—SOME SPECULATIONS ON THE PHENOMENA SUGGESTED BY A GEOLOGICAL STUDY OF VESUVIUS AND MONTE SOMMA.

By H. J. JOHNSTON-LAVIS, M.D., F.G.S., etc.

DISREGARDING for convenience the internal volcanic forces of the earth, let us take for granted that we have an unlimited supply of fused silicates at a very high temperature; what will be the changes and effects produced in the escape of such matters upon the earth's surface?

That, at the great sources of volcanic material the igneous mass is in a completely fused state there can hardly exist any doubt. By this is meant that the magma is an intimate mixture of various chemical elements and compounds that have not yet assumed any other than the fluid state, or, in other words, that the molecules move freely amongst each other and have not arranged themselves in any definite crystalline form.

One of the most important questions that first arises, and is not susceptible of complete response, is whether this fused magma contains aqueous matter in "solution"?[1]

If we must really regard granite as a primary igneous rock, the presence of water cavities in the quartz might certainly seem to prove the existence of that compound in the original fused magma. We must nevertheless remember that such may have been absorbed from the aquiferous strata in the neighbourhood of the granite if intrusive; or supposing such a rock to be the original earth's crust, the question carries us beyond safe speculation. Even admitting that a small portion of aqueous matter is mixed in the fused magma, it is hardly probable that it is sufficient to account for the large amount of vapour escaping during explosive and even tranquil volcanic activity.

If we take 25 kilometers as the thickness of the earth's solid crust traversed by the igneous matter before its exit, we shall have made but a very moderate estimate. If we make a rough calculation of what amount of material can be contained within a volcanic chimney 25 kilometers long together with its ramifications, with a diameter equal to any of the cores seen in denuded examples of old volcanoes, we shall see that the quantity is very great.

Let us suppose the area of the section of the chimney equal the area of section of a lava stream flowing from it; then before that part of the mass that enters the lower extremity can reach the surface, a lava stream will have been thrown out and have flowed 25 kilometers long.

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[1] *By "solution"* is meant a condition similar to the solution of CO^2 in water.

We therefore see that the igneous magma must remain for a very considerable time during its passage upwards, in contact with the walls of the chimney, even when we have to deal with a rapid outpour of lava. If, on the other hand, the upper outlet be blocked either by the cooling of the contained mass, or the crumbling in of its sides, a very extensive column of igneous magma may remain for an indefinite time without much disturbance.

Now the walls of this tubular channel will be composed of varied kinds of rock, many of which may be rich water-bearing strata. We have therefore a superheated fluid igneous magma under enormous and varying pressure in contact with solid rocks of different chemical composition; conditions more favourable could hardly be conceived for chemical interchange.

There would take place the gradual assimilation of water into the fluid rock in quantities proportional to the temperature, pressure, supply, and chemical composition of the fused mass, but probably most dependent upon the length of exposure. When a great eruption of lava was taking place, a given mass might traverse the whole of the chimney in a few days, or if the volcano were semi-extinct, as Somma was before A.D. 79, the contact of the two materials might be prolonged over centuries. In the first instance, where little time was given for water absorption, we should expect a gradual outpour of fluid rock, such as is usually the case in that type of eruption, whereas in the second the enormous expansion of volatile matter due to the extensive imbibition of many years, would be so great and take place with such rapidity that in escaping from the tube it would carry the fluid magma with it.

The mass would naturally have lost much of its heat by raising the absorbed water to its own temperature, and during the eruption this loss would be great by the conversion of the liquid into gaseous water. The rock torn into fragments as the result of this rapid expansion would still experience diminution of pressure, and therefore temperature, in their ascent, so that, long before crystals or even microliths could form, the rock must have solidified as a vitreous or at least semi-vitreous mass.

If the conditions for the absorbing of water be less favourable, or, when two paroxysmal eruptions rapidly follow each other, then the explosions will take place with much less violence. At the same time less heat will be lost in expansion, and so the cooling of the mass will take place more gradually, allowing the formation and growth of microliths and crystals. As the rock is less rich in volatile matter, it remains in a plastic state longer, so as to permit of the escape of what few bubbles there are, the rock that results will assume a more compact and crystalline character. By such gradations we pass through what has been called vitreous, microlitic, compact pumice, to pumiceous scoria, and thence to true lava and scoria.

Lava we have seen to be rather the result of chronic activity; which is obviously due to two causes. First, as there is a continual dribbling forth from time to time of fluid rock, that portion occupying the chimney is gradually changed, so as to leave little time for hydration of the magma. Secondly, whatever aqueous matter was absorbed, would be rapidly got rid of as bubbles which rise to the surface of the fluid column and there escape as the "smoke" of the volcano.

In chronic activity the lava column may be kept a long time, independent of constant loss, at a high temperature, from the heat derived from below; so that crystallization can have its full play, producing highly crystalline rocks. Thus we see at Vesuvius that the small streams that issue after a long period of gentle activity are exceedingly rich in large leucites and pyroxenes, whereas long streams after an inactive state are fine-grained. With the coarse crystalline lavas all the water has been boiled off so that no scoria forms, as in that of 1858,[1] whereas in the fine-grained vapour-bearing ones, as 1631 and 1872, there is an abundance of scoria formed on their surface.

Dyke-forming material may be regarded as a lava suddenly cooled at its surfaces as a vitreous salband. The central portion on the contrary cools slowly under comparatively favourable conditions, compared with the simultaneous outflowing of lava in another direction, while, though the latter may be fine-grained, the former may have a very coarse crystalline structure.

All these variations in eruptive phenomena do not exclude those other conditions that exist in the fluid (?) interior of the earth, or at least in the reservoirs from which the primary matter must be derived. The upheaval of mountain chains, a certain class of widespread earthquakes, the apparent relation of eruptive periods to the lunar tides, and barometric pressure, may all be independent of the secondary or modifying causes of eruptive activity.

If, as is generally the case, the volcano be situated near the sea, there is no reason why the old theory of percolation of sea-water may not in part be true as a cause of eruption. We, however, must not look upon water as the primary determining agent, for if the seismic forces are capable of upheaving the great mountain ranges of the globe, surely they can fissure the crust of the earth and squeeze out a little fluid rock. Such escape might take place quite tranquilly, were the igneous magma not brought into contact with water-bearing strata, and probably sometimes does so, if we may judge from those extensive sheets of basalt in Idaho, U.S.A., without the sign of a cinder cone.

That sea-water really reaches the lava, and causes its more violent exit, seems certainly supported by the fact that the upholders of that theory have made so much use of, namely, the quantity of H Cl, with chlorides and sulphates of the alkalies so abundant in volcanic vapour, and around fumaroles. Most valuable evidence could be obtained by the study of the saline crusts and exhalations, if any exist, that occur at the few inland volcanoes that are at present active, as, for instance, Jorullo in Mexico, and some others. It would also be worth studying the proportion of alkalies in any given series of eruptive deposits, to endeavour to discover whether the amount of water-vapour that escapes bore any relation to these. This remark will be better understood when we remember the vast amount of HCl and SO_2 that escapes in the "smoke" of a volcano, which, if derived from the decomposition of sea salts, must certainly represent a considerable amount of alkalies and alkaline earths, which should be found in the igneous rock.

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[1] Judd, Volcanoes, 1881, p. 211.

So far we have only studied the modifications brought about between water and substances held in solution in it, and the igneous magma; there is therefore left the consideration of the interchanges that may take place between that latter and various solid rocks.

We should naturally expect that the delayed contact of an igneous mass with the walls of its containing tube, if they should consist of highly siliceous rocks, would not be the same as with walls of magnesian limestone or other earthy carbonates. Neither should we expect that either would result in the same way if inclosed in a tube of argillaceous strata. We must remember that in all probability the tube may traverse all these materials, but still one particular class of rocks may predominate.

This certainly seems a more reasonable explanation than that of Von Richthofen,[1] which supposed one silicate floating on another. If such were the case, we should expect distinct groups of igneous rocks instead of those imperceptible gradations that puzzle all the experience of our chemists and petrologists. Did any laboratory experiment, any smelting-furnace or glass-factory, show that one silicate floats on another like oil on water? I think the most extraordinary complexity of the composition of the crystallized silicates is alone sufficient to prevent our supposing the separation of bodies so nearly allied chemically. It is not astonishing to see substances like oil floating on water, or the latter on chloroform, when we remember what a very different arrangement of molecules each of these bodies have when compared together, whereas glycerine, alcohol, ether, chloroform, bodies nearly allied, mix with facility. Nevertheless, these are not so similar as one silicate to another.

Those geologists who have studied the late Tertiary volcanoes of Italy have always remarked a great similarity between their products. True it is that we have basalts, dolerites, leucilites, andesites, trachytes, and rhyolites; yet the great majority of them range between the dolerite and non-quartziferous and rather basic trachyte, whilst the basalts and quartziferous lavas are confined to small and isolated patches. The remarkable similarity presented by the leucitic rocks in a range of volcanoes parallel to the mountain axis, and therefore bursting through similar strata, is worthy of notice. Perhaps not less so than the fact that all the smaller volcanoes that have been formed chiefly by spasmodic or paroxysmal eruptions are of the trachytic type or phonolitic at the mo whereas those of more permanent activity, as Etna, Strombo-li, Vesuvius, Roccamonfina, and some of the Roman ones, have a much more basic character.[1] Whatever may really be the cause, in this variation of volcanic ejectamenta in this district, it would be unsafe to dogmatize upon, nevertheless the above facts are worthy of thinking over and carefully considering.

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[1] It will be seen that even were the earlier part of the mountain pumiceous, it certainly was not trachytic with products whose silica percentage is beneath 55 per cent.—Judd, Volcanoes, 1881, p. 204.

We have somewhat erred from our way in endeavouring to show that a fluid igneous matter might be modified by the strata it traverses; it now remains to study the igneous fluid upon the neighbouring solid rocks. All geologists who have studied metamorphic rocks have always recognized that the changes they had undergone, had been the result of heat, pressure, and chemical replacement. Perhaps one of the most interesting of such examples are the series of erratic blocks ejected during paroxysmal eruptions from Monte Somma. In some cases we may see that the rock ejected is indistinguishable from what may be collected in the Castellamare limestone quarries. From this we may trace all gradations to finding the structure and composition entirely changed, having its cavities lined by such minerals as leucite or pyroxene that are normal elements of the igneous rock, or anorthite, meionite, and many others that may result from the combination of leucitic, augitic, or other material with the lime and magnesia of the Apennine limestone. That such changes take place with considerable rapidity is proved by the pyroxenic or micaceous crust to fragments of limestone enveloped accidentally in lava streams, specimens of which are not rare to find.

Another fact, at first somewhat difficult to grasp, is the different proportion or variety of minerals volcanic rocks may contain, yet meanwhile have the same general composition.

That simply temperature is not the sole element in determining the fusion or crystallization of a mineral is well demonstrated by the species leucite and sanidine. Thus leucite, according to the experiments of Messrs. Fouqué et Lévy, crystallizes at a white heat, whereas the felspars only did so at a red. Such order is also borne out by many leucitic rocks, yet it is not an uncommon thing to find a sanidine crystal partly or entirely enveloped in one of leucite, not only as micro- but also as macroscopic crystals. This certainly shows that the two minerals may follow each other in their separation or may increase contemporaneously, and therefore must be due to some other variation than that of temperature. Is it not possible that the combination of certain temperatures, pressures, presence of water, etc., may favour the formation of some minerals and retard others; for why should amphibole and pyroxene replace each other with so much facility?

Let us suppose that the conditions are suitable to the crystallization of a mineral from a fused mass of mixed silicates, which differs from it in the proportion of its elements. This first mineral, which we will call A, will continue to crystallize until it has exhausted to a certain extent the amorphous base, leaving a residue that approaches very near the composition of the second mineral, B. Now if the conditions are favourable, B will exhaust the residue until that approaches in composition to C; and so on.

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[1] *Scrope* seemed inclined to accept a somewhat similar idea.—Volcanoes, 1825, *p. 145.*

If, however, the conditions that were favourable to the formation of more A were prevented from continuing, the residue would not perhaps be suitable to the formation of B, but to another mineral which we will call X. This X may, in its turn, leave a residue from which would not form C but another species Y. We should in this way have two rocks derived from the same magma and having the same chemical composition, yet differing widely in their mineral components, which using the above letters could be represented thus:

$$A + B + C = A + X + Y.$$

V.—On the Discovery of Human Bones and Ornaments in a Cave in the Great Ormes Head.

By the Rev. Canon A. H. Winnington Ingram, F.G.S.

A CAVE in the south escarpment of the Great Ormes Head has been in gradual process of exploration by a person named Kendrick. In its silt and breccia he has discovered fragments of human skeletons, indicating by their dimensions that the individuals to whom they belonged were about five feet six inches in height. Some of their tibiæ are still to be seen imbedded *in situ.* There has also been found a considerable quantity of swine's teeth, each marked on the fang with from four to six transverse lines, and perforated at the extremity with a hole through which ran probably a tendon of a reindeer or some other ligament stringing them together as a necklace. There is a similar one, composed of *human* teeth, in the Christie Collection in the British Museum, worn by the inhabitants of the Solomon Islands. From the same cave deposit there have been extracted several bears' teeth, with a hole in each of them for their suspension as ear-rings, and two lower equine jaws with the enamel of the four incisors highly polished, and with zigzag marks on the surface of the maxillary bone. These were probably hung also from the necks of the cave-men as ornaments.[1] The whole cavern, or a portion of it, has been considered to have formed a burial-place for some Iberian tribe; but the careless and irreverent manner in which the dead in it appear to have been disposed of seems to indicate that it might have been the habitation of a race of cave-men akin to the Eskimos, whom Professor Boyd Dawkins, in his "Early Man in Britain," describes as so indifferent to the sepulture of their deceased relatives that they sometimes cover up their bodies with snow and leave them to be eaten by dogs or foxes. The cave, which contains a natural reservoir of water, has only been partially excavated, and further researches seem most desirable, as they might lead to the finding of very important relics of its original inhabitants, as well as settle any doubts which may have arisen as to the accuracy of the present explorer's statement, on which the truth of the discovery of the above-mentioned remains in that particular cave rests.

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[1] In the same way as the natives of New Guinea wear lower human jaws as bracelets.

VI.—ON "WINGLESS BIRDS," FOSSIL AND RECENT; AND A FEW WORDS ON BIRDS AS A CLASS.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

(Read before the Geologists' Association, May 1st, 1885.)

BEFORE offering a short account of the Struthious, or Ostrich-like Birds, commonly called "Wingless Birds," I propose to say a few words about Birds as a class.

Every one who has paid attention to the anatomy of Birds has been struck by the marvellous uniformity of the Class. Embracing as it does almost countless numbers of species, these are found upon examination to pass insensibly, by the most delicate differences, the one into the other, so that it often is most difficult to distinguish genera and species.

"Though this class," says Prof. Huxley, "contains a great number of specific forms, the structual modifications which they present are of comparatively little importance: any two birds which can be selected differing from one another less than the extreme types of LACERTILIA, and hardly more than the extreme types of CHELONIA do."

If we take up a bird's skull, we shall find that the vertebral column articulates to the head by a single occipital condyle. That each ramus of the lower jaw is composed of a number of pieces which are distinct in the embryo: the jaw itself being united to the skull, not directly, but by the intervention of the "quadrate bone," as in reptiles.

That the fore-limb (*manus*) in no existing bird possesses more than three fingers, or digits, and the metacarpal bones are anchylosed together. Also we notice that the fore-limb in all living birds is useless as an organ of prehension, and that in most it serves as an organ of flight.

That the hind-limb in all birds has the ankle-joint between the bones of the tarsus; the astragalus and calcaneum uniting with the distal end of the tibia and the lower bones with the metatarsus, which in birds is called the "tarso-metatarsal" bone.

[The heart has 2 auricles and 2 ventricles, the right and left sides being completely separated from each other; nor is there any communication between the pulmonary and systemic circulation as there is in reptiles.

The respiratory organs are in the form of spongy cellular lungs, not freely suspended in pleural sacs, and the bronchi open on the surface with a number of air-sacs, placed in different parts of the body.]

All birds are oviparous, none bringing forth their young alive, or being ovoviviparous, as is the case with some of the reptilia.

All birds are provided with an epidermic covering specially modified so as to constitute what is known as "feathers."

Lightness and strength characterize the bones of the bird's skeleton. The walls of the bones, although very thin, contain a large amount of phosphate of lime, which gives them great compactness.

The absence of marrow in many of the bones, and its replacement by air-cells, also gives great lightness to the bird's skeleton.

Peculiarities of Vertebral Column in Birds.—The cervical region has seven vertebræ constantly in man and other mammalia; but in birds the neck is greatly elongated, and has from 8 to 23 vertebræ! The neck is long and flexible, and with the beak is used in place of the fore-limbs and hands. The vertebræ are convex from above downwards, and concave from side to side, in front; whilst the posterior surface is concave from above downwards, and convex from side to side.

The dorsal vertebræ are from 6 to 10 in number; the anterior 4 or 5 are anchylosed together to give support to the wings. All the vertebræ between the last dorsal and the first caudal (from 9 to 20) are anchylosed together to form a bone which is known as the sacrum. To this the iliac bones are anchylosed along the whole length, giving perfect immobility to this region of the spine and to the pelvis.

The Tail.—The caudal or coccygeal vertebræ vary from 8 to 10 in number, and are moveable upon one another. The "ploughshare-bone" has several anchylosed vertebræ in it. This bears the great *rectrices*, or quills, of the tail; but in cursorial birds, and birds that do not fly, this is not developed.

The tail in *Archæopteryx* consists of 20 caudal vertebræ, each joint having a pair of feathers, one on each side. The tail of embryo birds is many-jointed and free, and so also is the tail in the auk and penguin.

Thorax and Fore-limb (*Wing*).—The thorax is bounded by the ribs, of which there are from 6 to 10 pairs. They articulate in front to the sternal ribs or costal cartilages ossified; these are moveably articulated to the sternum, giving freedom to the respiratory movements of the heart and lungs.

In front is the expanded sternum, or breast-bone, which in all birds that fly has a greatly developed median ridge or keel to which the pectoral muscles are attached, which move the wings. This keeled breast-bone or sternum is so characteristic of birds of flight as to cause all those birds which possess it to be classed in the division CARINATÆ, or keeled birds, whilst the crest is not produced in birds which do not fly, as, for example, the Ostrich and its allies, which are consequently classed under the RATITÆ, or boat-breasted birds, being destitute of a keel to the sternum. At the anterior angles of the sternum are fixed the two coracoids, which help to form "the pectoral arch."

The *pectoral arch* consists of the shoulder-blades or scapulæ, the collar-bones or clavicles, called also the furculum, or 'merry thought,' and the coracoids, one on each side.

The shoulder-blade or scapula has no ridge, and is a simple strap-like bone. It helps to form the glenoid cavity for the humerus.

The coracoid bones are the two strongest bones in the scapular arch; they receive the downward pull of the muscles of the wing of the bird in flight. The "clavicles" (which are usually united in one bone, the furculum) also act as supports, and tend to resist,—by their union with the shoulder, at each end, and with the ridge of the sternum in the centre,—the pressure of the wing-muscles in flight. The bones of the wing, or fore-limb, are the humerus, the radius and ulna, the former of which is small and slender. The carpus consists of three bones (the metacarpals), the two outermost digits are absent, and the remaining three phalanges are anchylosed together. The thumb sometimes carries a claw, as in the Rhea, Ostrich, Screamer, etc.

In the young chick we find the radial and ulnar carpal bones are distinct. These become united with the radius and ulna in the adult.

In *Archæopteryx* they are seen to be distinct, and all three phalanges are provided with claws. (See Dames on the Berlin *Archæopteryx.*)

The *pelvic arch*, and hind-limb.—The posterior, or "pelvic arch," is composed of the ilium, the ischium, and the pubis; these bones are always anchylosed together and united to the sacral region of the spine.

The Ostrich is the only bird in which the two pubic bones are united by a *symphysis-pubis.* The hind-limb consists of the femur, tibia and fibula, tarsus, metatarsus, and phalanges. The femur in birds is a short bone. The tibia is long, and has a thin tapering fibula attached to it.

The ankle-joint is placed, as in Reptiles, between the proximal and distal portions of the tarsus, the astragalus and calcaneum being united with the tibia and the distal portion to the 2nd, 3rd, and 4th metatarsals to form the 'tarso-metatarsal bone.'

The leg in birds varies enormously in length, as may be seen by comparing the Waders and Perchers.

There is a remarkable constancy in the number of joints to the toes of the foot in almost all birds, thus:—I. The hallux, or hind-toe (=to the thumb), has two joints; the II. inner toe has 3 joints; the III. or middle-toe has 4 joints; and the IV., or outer-toe, has 5 joints. [The fifth toe is never present, and the 'hallux' is frequently absent.]

But no rule is without exceptions. Thus the "Swifts" have never more than 3 joints to the third and fourth toes. The "Goatsucker" has 2 joints less on the outer or 4th toe. The inner big-toe (II.) and the hallux disappear in the Ostrich.

The hallux is frequently absent both in Natatorial (Swimming) and in Cursorial (or Running) birds. [Compare the Avian foot and pelvis with that of the Dinosaurs.]

Scarcity of Avian Fossils.—Although we have positive evidence of the existence of Birds in the Jurassic period, yet their presence, as fossils, is most uncommon.

It was at one time surmised that the numerous bipedal, three-toed foot-prints, preserved upon the surface of Connecticut Sandstone of Triassic age, had been made by birds; but it may now be argued, with equal probability, that these tracks may have been left by Dinosaurian reptiles, having tridactyle hind-feet upon which they very frequently, if not constantly, progressed, in an erect position, as seems to have been the habit of *Iguanodon* and several others.

(1). The earliest-known Bird with which we are acquainted is still the *Archæopteryx.*

At first only a single Bird's feather was found in the Lithographic Slate of Solenhofen and named (in 1861 by H. von Meyer) *Archæopteryx lithographica.*

In the same year, the almost entire skeleton of a curious long-tailed bird was discovered by Dr. Häberlein, and described by Prof. A. Wagner, as a new "feathered *Reptile*" (*Griphosaurus problematicus*, A. Wag.). In November, 1862, its *Avian* affinities were fully established by Prof. Owen (Phil. Trans. 1863, pp. 33–47, plates i.–iv.), and the Bird now forms the type of a new order of Birds, the SAURURÆ, or long-tailed lizard-like Birds.

It was shrewdly suspected (from the presence in the slab of a small detached maxillary bone with teeth), that *Archæopteryx* departed not only from ordinary birds, in the long and lizard-like tail, but also in having its jaws armed with teeth. The discovery in 1879 of a second specimen of *Archæopteryx* (now fortunately secured for the Berlin Museum) fully confirms this very important point, and we know now from the researches of Prof. W. Dames in Berlin (GEOL. MAG. 1882, p. 566–568),[1] that *Archæopteryx* had from 10 to 12 teeth in the maxillary and pre-maxillary border on each side, and three or more teeth in the lower jaw also.

This *oldest Jurassic Bird* presents the following peculiarities, viz.,

1. The presence of true teeth in the skull and lower jaw.
2. The vertebræ biconcave.
3. A well-ossified, broad sternum.
4. Three free digits in each manus, armed with claws.
5. Pelvic bones separate.
6. The distal end of the fibula in front of the tibia.
7. Metatarsals separate or imperfectly united.
8. These with free metacarpals in the wing, and the
9. Long lizard-like tail, show clearly that we have in *Archæopteryx* a most remarkable form, which as a bird has most reptilian affinities.

(2). The next evidence of Bird-remains consists of some detached bones of a true Bird from the Wealden of Sussex, but they are not sufficiently important to be discussed here.[2]

(3). Equally fragmentary are the remains of the *Pelagornis Barrettii* from the Cambridge Greensand.

(4). But from the Middle and Upper Cretaceous of New Jersey of Western Kansas and from Texas in the United States, we obtain evidence of no fewer than eight genera and twenty species of Birds offering most striking and remarkable characters.

We are indebted to the labours of Prof. O. C. Marsh for this wonderful addition to our knowledge of the extinct birds of the

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[1] See also GEOL. MAG. 1884, Decade III. Vol. I. pp. 418-424, Plate XIV.

[2] "Remains of Birds," Mantell (*Palæornis Cliftii*), Geol. Trans. 2nd series, vol. v. t. 13. Wealden, Tilgate Forest. Preserved in the Geological Collection of the British Museum (Natural History).

Secondary Rocks, of which the genera *Hesperornis* and *Ichthyornis* present two very remarkable types.

The first (*Hesperornis*) had only a rudimentary wing, was nearly six feet high, had a flat sternum, and its jaws were armed with teeth implanted in grooves. It was a huge fish-eating Diver.

The second (*Ichthyornis*) possessed very powerful wings and a keeled sternum; and its jaws were armed with teeth in distinct sockets. The vertebræ are biconcave.

These remarkable birds form a second order, the ODONTORNITHES.[1]

They have teeth, but, unlike *Archæopteryx*, they have not the long lizard-like tail.

Upwards of thirty genera of birds have been described from Eocene-Tertiary strata, but as most of these are like the great bulk of our modern birds, I will only specially refer to one or two.

Two species of *Gastornis* are now known, one from Paris and one from Belgium. It was originally believed to be a Struthious bird, like the Ostrich: it is now considered a hugh wading or Anserine bird. Mr. E. T. Newton, F.G.S., has also discovered some similar Bird-remains in the Lower Eocene, Woolwich Series, near London (not yet published). Sir R. Owen has described three bird-remains of very great interest, from the London Clay, namely *Argillornis longipennis*, a fish-eating (serrated or tooth-billed) bird larger than the Albatross: a serrated-billed bird (also no doubt fish-eating) named *Odontopteryx toliapicus*. Sir Richard Owen has also described an imperfect skull of a great Struthious Bird, *Dasornis londiniensis*, with affinities to *Dinornis*; whilst in strata of Eocene age in New Mexico Prof. Cope records the discovery of *Diatryma gigantea*, a wingless bird twice the size of the living Ostrich.

We may pass over the Miocene Birds, which are mainly interesting as showing a modified distribution for modern Birds—as, for example, the occurrence of true Ostrich-bones fossil in the Newer Miocene of the Siwalik Hills in India.

We come, however, in late Tertiary times upon a group of Birds (very scantily represented in the *older* Tertiaries) with representatives living to-day in widely separated geographical areas.

These form the Order RATITÆ or raft-breasted birds having no keel to the sternum.

In New Zealand we have the Family Dinornithidæ (*Dinornis*), all —or nearly all—large cursorial birds, the wings absent, or *quite rudimentary*, and useless for flight.

In Madagascar we have the extinct *Æpyornis* closely related to *Dinornis*.

In the Mascarene Islands we have remains of another wingless bird, *Erythromachus Leguati*, allied to the living *Apteryx*.

In the Bone-caves of Wellington, New South Wales, remains of *Dromæornis* and of *Dromæus* have been found.

In the Bone-caves of Brazil, remains of a species of *Rhæa* have been met with.

In the Eocene deposits of New Mexico we have Cope's *Diatryma gigantea*.

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[1] *See* GEOL. MAG. 1876, pp. 49–53, Pl. II.; Op. cit. 1880, pp. 522–526.

Lastly, in the Eocene of England (London Clay of Sheppey) we have Owen's *Dasornis londiniensis.*

The following summary of the class Aves gives the leading characters by which the four great Orders are distinguished.

Order I. Sauruææ (Lizard-tailed Birds).

a. The metacarpals not anchylosed together, the tail longer than the body, jaws furnished with teeth. Three free digits in the manus, all with claws; vertebræ biconcave.

Archæopterygidæ. Ex. *Archæopteryx*, Owen.

Order II. Odontornithes (Toothed Birds).

Sub-order 1. *Odontolcæ.* No wings; teeth in grooves; sternum flat. Ex. *Hesperornis*, Marsh.

Sub-order 2. Odontotormæ. Possessing powerful wings; sternum keeled; teeth in distinct sockets; vertebræ biconcave. Ex. *Ichthyornis*, Marsh.

Order III. Ratitæ (Raft-breasted Birds).

A. Sternum devoid of a keel.
a. The wing with a rudimentary or a very short humerus, and with not more than one ungual phalange.
b. The hallux present.
1. Apterygidæ. Ex. *Apteryx*, 4 species; *Erythromachus* (1 sp.).
a. Wings absent or rudimentary.
b. No hallux present.[1]
2. Dinornithidæ. Ex. *Dinornis*, 7 sp.; *Mionornis*, 2 sp.
a. The hallux present.
3. Palapterygidæ. Ex. *Palapteryx*, 2 sp.; *Euryapteryx*, 2 sp. (Eocene, England) *Dasornis*, 1 sp.; (Madagascar) *Æpyornis*, 3 sp.
a. Skull surmounted by a bony crest or helmet.
b. No hallux.
c. Neck bare. *Casuarius.*
4. Casuariidæ. "Cassowary," 9 sp.
a. Neck feathered.
5. Dromæidæ. *Dromæus*, the Emeu, 2 sp.
a. The wing with a long humerus and with two ungual phalanges.
b. The ischia uniting immediately beneath the sacrum; the pubes free.
6. Rheidæ. *Rhea*, "American Ostrich," 3 species.
a. The ischia free and the pubes uniting in a ventral symphysis.
7. Struthionidæ. *Struthio*, 1 sp.? African Ostrich.
Diatryma gigantea (Cope). Fossil Eocene, New Mexico.

Order IV. Carinatæ. Birds having their *sternum provided with a keel*: comprising some 105 families and about 8700 species, embracing all modern birds, *save the Ratitæ*, and some fossil species. Of these about 5000 do not exceed the size of a sparrow.

The subjoined list will serve as a rough summary of the appearance in time of the Class Aves.

Appearance in Time of Birds.

Triassic formation, Bird-like Bipedal tracks or Foot-prints.
Jurassic formation (Solenhofen Limestone), *Archæopteryx macrura*, Owen.
Cretaceous formation (Wealden), "*Palæornis Cliftii*," Mantell.
(Lr. Greensand, Cambridge), *Pelagornis Barrettii.*
M. Cretaceous (N. America), *Apatornis celer*, Marsh.
,, Western Kansas, *Baptornis advenus* ,,
,, ,, *Hesperornis regalis* ,,

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[1] This character fails us here, for *Dinornis* seems to have possessed a hind-toe.

M. Cretaceous,	W. Kansas, *Hesperornis crassipes* ,,
,,	,, ,, *gracilis* ,,
,,	N.W. Kansas, *Ichthyornis dispar* ,,
,,	Western Kansas ,, *agilis* ,,
,,	,, ,, *anceps* ,,
,,	Texas, U.S.A. ,, *lentus* ,,
,,	Kansas ,, *tener* ,,
,,	N.W. Kansas ,, *validus* ,,
,,	Western Kansas ,, *victor* ,,
U. Cretaceous,	New Jersey, U.S.A., *Laornis Edvardsianus*, Marsh.
,,	,, ,, *Palæotringa littoralis* ,,
,,	,, ,, ,, *vagans* ,,
,,	,, ,, ,, *vetus* ,,
,,	,, ,, *Telmatornis priscus* ,,
,,	,, ,, ,, *affinis* ,,
,,	,, ,, *Graculavus velox* ,,
,,	,, ,, ,, *pumilus* ,,
Eocene.	Meudon, Paris, *Gastornis parisiensis*.
,,	Belgium, *Gastornis Edwardsii*, Dollo.
,,	Sheppey, *Lithornis vulturinus*, Owen.
,,	(London Clay), *Argillornis longipennis*, Owen ; *L* *londiniensis*, Owen ; *Odontopteryx toliapicus*, *Halcyon* ; *Laridæ* (sp.), Gulls? *Ardeidæ*, Herons
,,	Hempstead (Freshwater marls), Isle of Wight, *Ptenorni*
,,	Hordwell, *Macrornis* (Seeley).
,,	Glarus (Plattenberg), *Protornis* (*Osteornis*).
,,	Paris Basin, *Agnopterus* (Flamingo ?), ext. ; *Cormo* *Coturnix* (2 sp.) ; *Falco* ; *Gypsornis* (*Rallidæ* ?) *Leptosomus* ; *Limosa* ; *Palæocircus*, ext. ; *Palæorty* *Pelidna* ; *Rallus* ; *Sitta* ; *Tringa* ?
,,	Aix, Provence, Fossil Eggs and Feathers.
,,	Lacustrine deposits, Armissan, in Languedoc, *Tetrao*.
,,	Apt, Provence, Bird remains indetermined.
,,	Marls of Ronzon, Auvergne. Various Bird remains.
,,	Swabian Alps (Fraas). Ditto.
,,	N. America, Wyoming (O. C. Marsh), 5 species of Bird
,,	New Mexico, U. States Territory, *Diatryma gigantea*,
Miocene.	France-Bourbonnais and Auvergne (remains of ne species of birds).
	Mentz, many identical forms.
	Berne, Freshwater deposits.
	Provence and Languedoc.
	(Bone-beds) Sansan in Gascony.
	Greece, Pikermi, Attica.
Newer Miocene.	Siwalik Hills, India. *Struthio*, sp. *Argala*. ? Corm
Miocene.	Steinheim, Bavaria, 8 sp. of birds. *Ibis*, *Ardea*, *Pal* *Anas* and *Pelecanus*.
Miocene.	N. America. All of them existing species.
Post-Pliocene.	New Zealand, *Dinornis*, *Palapteryx*.
Do.	Madagascar, *Æpyornis* (3 species).
Do.	Mascarene Islands, *Erythromachus*, etc.
Do.	Brazil (Bone-caves), *Rhea*, sp.
Do.	Australia (Caves), *Dromæornis*, *Dromæus*.

The labours of many Naturalists combined, of whom the na Sclater, Wallace, Newton, and some others should be speciall tioned, have enabled us to map out the world into six great N History Regions, to which, strange to say, *flying birds*, wi exceptions, readily correspond in their geographical distributio

THE GEOGRAPHICAL DISTRIBUTION OF BIRDS (AFTER DR. P. LUTLEY SCLATER, F.R.S.)

V.

NEARCTIC.

6,500,000 square miles.

660 species.

1 sp.
= 9,000 sq. m.

(Ratitæ 1 foss.)

Regions.	Species.
I.	650
II.	1,250
III.	1,500
IV.	1,000
V.	660
VI.	2,250
	7,310
Additional species	190
	7,500

I.

PALÆARCTIC.

14,000,000 square miles.

650 species.

1 sp.
= 21,000 sq. m.

[Ratitæ 1 v.] 1 extinct.

VI.

NEOTROPICAL.[2]

5,500,000 square miles.

2,250 species.

1 sp.
= 24,000 sq. m.

Ratitæ 3 sp. v. 1 ext.

II.

ETHIOPIAN.[2]

12,000,000 square miles.

1,250 species.

1 sp.
= 9,600 sq. m.

Ratitæ 1 v. 4 sp. ext.

III.

INDIAN.[2]

4,000,000 square miles.

1,500 species.

1 sp.
= 2,600 sq. m.

Ratitæ 1 ext.

IV.

AUSTRALIAN.[2]

3,000,000 square miles.

1,000 species.

1 sp.
= 3,000 sq. m.

Ratitæ 14 sp. v. 16 ext.

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[1] See Dr. P. Lutley Sclater, F.R.S., Journ. Proc. Linn. Soc. (Zoology), vol. ii. pp. 130-145 (1858). [The whole avifauna amounted in 1858 to 7500 (Sclater); and to 8750 species (Newton) in 1875.]

[2] Mr. R. B. Sharpe informs me that in all these four provinces enormous increase in species in the last 20 years has taken place. The total number of Birds at present known is not less than 11,000 species.

These Regions embrace:—

I. The Palæarctic, consisting of Europe and Asia, with Africa, down to the tropic of Cancer, also Northern Arabia, Persia, Tibet, and China. In North Africa, Arabia, and Persia there is evidence of the *Ostrich* in modern and ancient times, although no doubt it is rarer now. We have also a fossil Ostrich *Dromornis* (Sheppey).

II. The Ethiopian Region, embracing all Africa and Arabia south of the tropic of Cancer and Madagascar with its adjacent islands. We have here the living Ostrich, and in Madagascar three if not four well-marked species of extinct Struthious Birds called *Æpyornis*, occurring in the newer Tertiary sand-drift deposits of this island.

III. The Indian Region, and the whole of Siam, with Borneo, Sumatra, the Philippines, etc., having one fossil Ostrich in the Sewalik Hills. There is also historic evidence of the former wider range of this Bird, from Persia into India itself.

IV. The Australian Region, comprising New Guinea, Celebes, Australia, Tasmania, New Zealand, etc.

This province in *living and extinct* forms of Struthious Birds is the richest in the world. It possesses

9	species of	Cassowary (*Casuarius*).	(living).
3	,,	Emeu (*Dromæus*).	
4	,,	*Apteryx* or "Kiwi."	
14	,,	*Dinornis*, *Palapteryx*, *Dromornis*, etc. (all extinct).	

V. The Nearctic Region embraces the great Continent of North America down to Mexico. It has no living Struthious Bird; but Prof. Cope has discovered in strata of Eocene age in New Mexico, a wingless Bird twice the size of the living Ostrich, named by him *Diatryma gigantea.*

VI. The Neotropical Region embraces Central and South America, and the West Indies: a region most rich in species of modern birds, and having three species of Struthiones, and one extinct form from the Caves of Brazil.

Power of Flight.—Nearly all living birds, as is very well known, possess the power of flight and have carinate breast-bones, to give attachment to the great pectoral muscles, without which the wings would be unable to beat the air in the rapid flight of the bird, and so sustain it above the earth.

But if a Carinate Bird is placed upon an island and has no enemies, and has habitually to seek its food upon the ground, the bird in time ceases to fly at all, and loses the carinated character of its sternum.[1]

This has happened in *Strigops* (one of the *Psittacidæ*), New Zealand; in the *Dodo* (*Didinæ*), Mauritius; the "*Solitaire*" (*Pezophus solitarius*), Rodriguez; the *Aphanapteryx* (a Rail), Mauritius; the

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[1] In the case of *Didunculus*, in the Island of Samoa, this little didine bird had carelessly taken to building its nest on the ground, but since the introduction of pigs and other animals, it has made an effort to save itself, and it now builds its nest higher up in the trees, and it may possibly survive adverse circumstances if man does not intervene. *Strigops* seems, on the contrary, doomed to extermination, building on or near the ground, and making no effort to fly or protect itself from its destroyers.

Cnemiornis (a gigantic goose), New Zealand; the *Aptornis* (a Rail), New Zealand; the *Notornis* (a Rail), New Zealand.

Again, a bird may have wings quite useless for the purpose of flight, and yet capable of being used for some other purpose, and so may develope a large keel on the sternum. For example, the Great Auk and the Penguin, although incapable of flight, use their rudimentary wings most vigorously when swimming in pursuit of fish, and have a very large keeled breast-bone.[1]

The *Hesperornis* had a perfectly flat sternum, wholly destitute of a keel, so that, even if it had a rudimentary wing, it was without any function, having no muscles to move it.

Whatever view we may adopt as to the origin of the *Ratitæ*, it is an undoubted fact that they occur, either recent or fossil, in each of the great regions of the globe.

This group must therefore be considered to be as old, if not probably more ancient than the *Carinatæ* among the Avian Class.

For unless we adopt the hypothesis of a separate origin for each family of the Raft-breasted Birds, we must admit that their inability either to fly or to swim, renders their distribution *by land*, as indispensable as in the case of the Mammalia: whereas those birds possessed of the power of flight may have crossed over a portion of old land, on the wing, after that land had become submerged, and so have peopled separate islands and continents.

Indeed Wallace so explains the habit of those migratory birds that twice annually cross the Channel, and also the Mediterranean Sea, by the theory that they are a part of a group of birds belonging to a much larger ancient land-surface (now no longer continuous), over which these birds moved with the seasons in search of food, from south to north, or from east to west, and *vice-versa*, and that their modern representatives simply follow the old road, although a part of that road is now under water.

But we must admit that the *Carinatæ* may justly claim for their remote ancestor the most ancient fossil bird we know *at present*, viz. the *Archæopteryx* from the Lithographic Stone of Solenhofen in Bavaria, a stratum of Upper Jurassic age. For although an aberrant form of bird, it possessed the foot of a true passerine bird, and enjoyed, in a small degree at least, the power of flight; whereas for the RATITÆ we have no more remote ancestor than Owen's Eocene *Dasornis londiniensis*, or Cope's *Diatryma gigantea* from the Eocene of New Mexico.

It seems probable, however, that *some of the footprints* on the American Triassic Sandstones may have been produced by Struthious birds, and Cope's discovery of *Diatryma gigantea* in the Eocene of New Mexico may be followed by the unearthing of more ancient evidence of RATITÆ in North America.

That the immediate predecessors to Birds were *Dinosauria* seems highly probable, and this view has been adopted by Professors Huxley, O. C. Marsh, and many other comparative anatomists.

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[1] The Guillemot may be seen at the Zoological Gardens using its wings when swimming in pursuit of fish.

Professor Marsh, writing upon *Archæopteryx* in the GEOL. MAG., 1881, says:—"The nearest approach to Birds now known would seem to be in the very small Dinosaurs from the American Jurassic. In some of these the separate bones of the skeleton cannot be distinguished with certainty from those of Jurassic Birds, if the skull is wanting, and even in this part the resemblance is striking. Some of these diminutive Dinosaurs were perhaps arboreal in habit, and the difference between them and the birds that lived with them may have been at first mainly one of feathers.

It is an interesting fact that all the Jurassic birds known, both from Europe and America, are *land birds*, while all from the Cretaceous are *aquatic forms*. The four oldest known birds, moreover, differ more widely from each other than do any two recent birds. These facts show that we may hope for most important discoveries in the future, especially from the Triassic, which has as yet furnished no authentic trace of birds. For the primitive forms of this class we must evidently look to the Palæozoic rocks." (O. C. Marsh upon "Jurassic Birds and their Allies," GEOL. MAG. 1881, pp. 485–487.)

VII.—WOODWARDIAN MUSEUM NOTES.

ON A PECULIAR FORM OF *HIPPOPOTAMUS MAJOR*, FOUND AT BARRINGTON.

By PHILIP LAKE, Esq., St. John's College, Cambridge.

IN the gravel at Barrington, about seven miles S.S.W. of Cambridge, numerous remains of *Hippopotamus* have been found, associated with *Rhinoceros*, *Bison*, *Cervus*, etc. A description of this gravel and its included fossils has been given by Mr. Fisher.[1] But since Mr. Fisher's paper was written, the number of bones and teeth found has been very largely increased. Most of these remains have been deposited in the Woodwardian Museum, Cambridge.

Among the Hippopotamus bones were six more or less perfect lower jaws. Five of these were typical specimens of *H. major*; but the sixth differs in character from the rest in several points, so much so in fact, that with a less perfect series of remains, it would perhaps have been described as a different species.

The jaw in question is tolerably perfect. The front part is complete; and the whole of the right ramus is present except the posterior lower portion. The condyle of this side, and also the anterior part of the *crochet*, are preserved. Only the front half of the left ramus of the jaw, as far as the first true molar, is complete; but we have also the condyle of this side, though the intermediate parts are missing. The incisors and canines are all present. On the right side the teeth left are the last premolar and the last two molars; on the left side, the last premolar and the first molar.

The chief points in which this jaw differs from an ordinary jaw of *H. major* are the very small size of the canines and incisors; the extent of the contraction and the small depth behind these; and the generally more feeble character of the jaw.

[1] Quart. Journ. Geol. Soc. 1879, vol. xxxv. p. 670.

molars are well worn, except the last, which, however, is some extent at all its cusps. Hence the animal must have ıture, though probably it had only just reached that age.

der to show the points of difference and resemblance arrived comparison of this jaw with that of an unmistakable *H. major*, drawn up the following table of measurements. The first of figures gives the measurements taken from the jaw in ı; the second, those taken from a typical jaw of *H. major*, ame length, in the Woodwardian Museum.

	The new jaw.		Jaw of *H. major*.	
	ft.	in.	ft.	in.
·Condyle to canine	1	9	1	9
–Canine to canine	1	4	1	5
; top just in front of the last premolar	0	5	0	5
t the widest part of the jaw just below point	0	9½*	0	10½
jaw at the last molar	0	5½	0	5½
jaw in front of last premolar	0	5½	0	7½
ı the part of the canine out of the socket ısured along the convex side)	0	4½	0	9
ɔf the part of the middle incisors out of socket	0	3½	0	8†

t of the left side of the jaw being missing here, about half an inch has been bring the width to what it actually would be if the specimen were perfect.

s is the observed length, but fully an inch is missing.

outer incisors of the jaw are perfect and project only an r even less, out of their sockets; but those in the typical jaw 'hich I have compared them are broken off. They are, how- ıuch thicker than in the new jaw.

molar teeth are exactly like those of *H. major*. Among the ı found separately at Barrington, there are small ones like belonging to the new jaw, and larger ones belonging to *jor*. But there is no passage between these two kinds. ; all the other remains there is no evidence of there being two ɔf Hippopotamus here.

iscussing the nature of this jaw, it may be assumed that it is new species, (2) an immature *H. major*, or (3) a female of *'or*.

ın scarcely be considered to be a new species, for the only ıce from *H. major* is the size of the canines and incisors and tural accompaniment of diminished weight and strength of r and of the canine sockets. There are enough of the other s to assume that if there were any other difference, we should ı to detect it. It is not likely that the remains of this kind popotamus should be restricted to canines and incisors, while so many other parts of *H. major*.

ın, the jaw does not seem to be immature. The dentition is ;he last molar having completely risen from its alveolus, and worn down to some extent. Moreover, among the other re- there is no passage between the two kinds of canines. r, the jaw is as long as that of a full-grown *H. major*.

In Parkinson's "Organic Remains"[1] there is described a peculiar Hippopotamus tusk, small and rounded, which he is inclined to refer to *H. minor*. But Sir Richard Owen[2] considers it to be simply the tusk of a young *H. major*; and states that these characters are found in the tusks of young animals of *H. amphibius*. But the tusks of the jaw under examination are not in the least rounded, and their section is just like that of an ordinary adult tusk, and they are grooved in the same way.

Assuming it then as proved, that this jaw is a jaw of *H. major*, and is not an immature one, it seems probable that it belongs to the female of *H. major*. It is common enough among the *Omnivora*, to which *Hippopotamus* belongs, to find the tusks much more strongly developed in the male than in the female. It is true that the travellers[3] who have had the best opportunities of studying *Hippopotamus amphibius* in its native state, do not notice any very marked difference in the size of the tusks of the two sexes (except so far as old males are concerned, these having enormous tusks). But there is nothing unlikely in supposing that, in the case of *H. major*, the female might have much smaller tusks than the male; and this is what the other evidence seems to point to.

NOTE.—Mr. R. Lydekker, B.A., F.G.S., concurs in the author's suggestion, that the relative differences in the dentition and form of the jaws in the Barrington *Hippopotami* are really only sexual, and it is therefore unnecessary to figure these remains, seeing that they are, in common with other Pleistocene examples, met with in this country, without reasonable doubt, referable to the living species of *Hippopotamus*, as long since pointed out by Prof. Boyd Dawkins, M.A., F.R.S. (see his Introduction to the Fossil Mammalia, Pal. Soc. Mon. 1866).—EDIT. GEOL. MAG.

REVIEWS.

I.—DENUDATION OF THE TWO AMERICAS. By T. MELLARD READE, C.E., F.G.S., etc. [Presidential Address to the Liverpool Geological Society, Session 1884–5.]

IN 1876 Mr. Mellard Reade delivered an address before the Liverpool Geological Society on the subject of "Geological Time." He then introduced some calculations relating to Chemical Denudation, and concluded that, on an average, 143½ tons of mineral matter are annually removed in solution from each square mile of the surface of England and Wales. From the Danube basin he estimated the annual loss by chemical denudation to be 90 tons per square mile. Extending his calculations now to the larger rivers of America, he concludes that from the drainage area of the Mississippi, 120 tons of solids in solution are removed from each square mile of surface per annum. It has been estimated that the basin of this

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[1] "Organic Remains," vol. iii. p. 376.
[2] "British Fossil Mammals and Birds," p. 403.
[3] *e.g.* Anderson, "Lake Ngami," p. 511.

American river is lowered at the rate of about one foot in 6000 years, but Mr. Reade observes that this rate has been calculated from the removal of sediment alone; and if we add to the matter removed mechanically that in solution, it will raise the rate to one foot in 4500 years. Of course much denudation is subterranean, and especially chemical denudation, but no doubt such losses lead eventually to a lowering of the ground by subsidence of material into fissures and cavities.

It is interesting to learn from the analysis of the Mississippi water that more than 23 millions of tons of silica are poured into the sea annually by this river, apart from sedimentary detritus.

Mr. Reade gives some particulars of the chemical constituents of the River Plate, but the amount of solid matter carried away in suspension by that river is not known. Particulars relating to the river St. Lawrence and the Amazons are also given.

With regard to the dispersion of river-sediments over the ocean bottom, Mr. Reade observes that while an admixture of sea-water with turbid freshwater tends to hasten the precipitation of the solid matters, yet it is very probable that the extremely divided solid matter will be carried far and wide by oceanic currents before it can settle to the bottom. Hence, he thinks, much of the argillaceous matter or "Red Clay" is more likely to be the "dust of continents" than volcanic débris, although no doubt volcanic materials are largely commingled with it; and he objects to the view that the Red Clays furnish in any way a proof of the *permanence* of oceanic areas. Much of the mineral matter carried to sea in solution is used up by pelagic animals, and thus eventually finds its way to the ocean-bottom; and had nature no means of redistributing these oceanic deposits by upheaval into land, the constitution of the rocks of the globe would be undergoing a gradual alteration.

II.—Catalogue of the Fossil Mammalia in the British Museum (Natural History).

Part I. Containing the Orders Primates, Cheiroptera, Insectivora, Carnivora, and Rodentia. By Richard Lydekker, B.A., F.G.S., etc. 8vo. pp. xxx. and 268. Illustrated by 33 Woodcuts. (London: Printed for the Trustees, 1885.)

In the first half of the present century, when the interest attaching to Fossil remains was mainly concentrated in the determination of their geological locality and exact stratigraphical position, but few naturalists at that time sought to correlate living animals and plants with the long line of ancestral forms whose remains occur in the various stratified rocks beneath our feet.

Thanks, however, to our great master, Lyell, geologists have been taught to recognize the fact, that the same agents which are in action to-day, Rain, Rivers and Sea, Frost and Snow, Cold and Heat, have been in operation ever since dry land appeared above the surface of the waters, and that instead of invoking one cataclysm after another, it was more reasonable to conceive an ever-recurring cycle of geological events, slowly succeeding each other, yet surely modifying the old land-surfaces and marine areas of our globe, by those gradual processes of elevation and subsidence, of denudation and deposition, such as we may observe to be taking place to-day. This law of Continuity in the physical events and changes on our globe, as demonstrated by Lyell, was with equal force and accuracy applied by our other great teacher, Charles Darwin, to the history of organic life upon the earth. Thus, instead of a series of separate creations and destructions of life, as taught by the earlier geologists, we have been led by the wider views of Forbes, Darwin, Wallace, and other naturalists, to recognize the great and fundamental fact, that there never has been a period of total extinction of life since its first dawn on our planet, and that the forms which we see around us are all derived by descent with modification from others more or less ancient, which existed ages before man's advent.

Thus, instead of a broken and disjointed history, our earth, whether viewed in its physical or biological aspect, presents a continuity of existence, which adds new interest to the study of its geological formations and its palæontological relics, since we are ever in search now of evidence of ancestral forms which may prove more or less closely related to those which we see actually living at the present day.

The publication of Part I. of Mr. Lydekker's Catalogue of the Fossil Mammalia in the British Museum (Natural History) forms the first instalment of a most valuable work prepared under what may very well be described as the new régime, in which every fossil form has been carefully compared with its allied existing species, and, wherever possible, referred to its living representative. By adopting this more sound and philosophical method, most important and valuable points, having reference to the first appearance in time, and also the former geographical limits of existing species, are brought out in a most interesting and instructive manner, and the former connection of old land-surfaces, now severed, is attested.

The Catalogue commences with the order PRIMATES, sub-order ANTHROPOIDEA. Under this division we have evidence of eight genera and eleven species of Monkeys; two only of which, from Brazil, are identified with existing species. They include the celebrated tooth of *Macacus pliocenus* described by Sir Richard Owen[1] from the Pleistocene Brickearth of Grays, Essex. The others are European or Indian forms. The Lemurs, now confined to Madagascar, are represented in the Collection by three Eocene species from France and S. Europe.

The fossil Bats (CHEIROPTERA) form a very limited group in the Collection. That found in England being the "horse-shoe Bat" (*Rhinolophus ferrum-equinum*), and four other species from France and Germany. Of the INSECTIVORA nine species are recorded fossil, including the common Mole, and two other species from France; and the "Desman," or *Myogale* from the Norfolk Forest Bed; the Shrew and the Hedgehog. The CARNIVORA occupy by far the larger space in the Catalogue (189 pages), and are represented in the Collection by 50 genera and 156 species. Of the 50 genera met with, the following living forms are represented by their fossil remains in the Collection, namely:—the Lion, Lynx, Ocelot, Jaguar, Leopard, Felis caffra, and Wild-Cat; the Hyæna, Wolf, Fox, Dog, Walrus, Seal, Otter, Badger, Glutton, Ermine, Polecat, Marten, Brown Bear, Grizzly Bear. The other genera are extinct, having no modern representative, such as, *Hyænodon*, *Pterodon*, *Machærodus*, *Cynodictis*, *Amphicyon*, *Simocyon*, and many others.

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[1] British Fossil Mammals, p. xlvi (1846).

If we except the bones of Bears and Hyænas, which occur in considerable abundance in caves in this country, and also in France and Germany, the remains of Carnivora are by no means common in a fossil state, when compared with those of the Herbivora. The explanation of this circumstance is to be found in the difference of habit; for whereas the Herbivora would be resting at night, and in consequence much more liable to be overtaken unawares by a sudden "freshet," or other catastrophe, the Carnivora, being mostly nocturnal in their habits, would become aware much sooner of any danger threatening their safety, and so seek refuge in time. Of the earlier deposits in which remains of the Mammalia have been met with, one of the most rich is that of the (Eocene) Phosphorite deposits of Quercy, Caylux, etc., in Central France, from which large numbers of most interesting forms have been procured. These phosphorites are met with as fissure deposits, and probably occupy hollows which once served as water-courses, into which ancient streams found their way by subterranean channels in Tertiary times, like those of Carinthia and Kentucky at the present day.

But the strata from which the largest number of specimens in the collection have been obtained are the Upper Miocene beds of the Siwalik Hills in India, most of the specimens from which were collected by the late Sir Proby T. Cautley, K.C.B., and partly described by the late Dr. Hugh Falconer, F.R.S. The Carnivora necessarily, however, form but a small proportion of this magnificent collection.

The RODENTIA occupy the remaining 55 pages of Mr. Lydekker's Catalogue, and comprise the Squirrels; Beavers; Dormice; the true Mice and Rats; Field-mice; the Viscacha (*Lagostomus*); the Porcupine; the "Paca" (*Cœlogenys*); the Capybara; the common Rabbit and the Hare, etc. In this division the most interesting British forms are the common Beaver once abundant in this country, even close to London, in the valley of the Lea at Walthamstow; and its great extinct ancestor the *Trogontherium Cuvieri* of the Norfolk Forest Bed.

The tailless Hare or "Pika" (*Lagomys*); the "Marmot" (*Spermophilus*); and the Lemming (*Lemmus*) are among the most interesting of the lesser Rodents; indicating as they do more Arctic conditions of climate, and also attesting the former connection existing between England and the Continent.

Mr. Lydekker's Catalogue must certainly prove of great value to to students and to men of science who desire to work at the collections in the National Museum, and although it merely relates to the British Museum Collection, yet it will serve as a very good basis for a study of the extinct and other fossil Mammalia belonging to those groups of which it treats. It is illustrated by thirty-three woodcuts of new or little-known forms, all of which are more or less fully described.

The general systematic arrangement followed is that laid down by Prof. Flower in his Catalogue of Specimens of Vertebrated Animals in the Museum of the Royal College of Surgeons, part ii. (1884).

We congratulate Mr. Lydekker upon the successful completion of Part I. of his work on the Fossil Mammalia, and we look forward with much interest to the continuation of his work, and trust that the second part, comprising the Artiodactyle Ungulates, may appear before the end of the present year.

REPORTS AND PROCEEDINGS.

I.—ROYAL SOCIETY OF LONDON.

"ON BEDS OF SPONGE-REMAINS IN THE LOWER AND UPPER GREENSAND OF THE SOUTH OF ENGLAND." By GEORGE JENNINGS HINDE, Ph.D., F.G.S. Communicated by HENRY WOODWARD, LL.D., F.R.S. (Received April 29, 1885.)

The author said:—I have pointed out in this paper the occurrence in the Lower and Upper Greensand strata of the Wealden area, the Isle of Wight and the south-western counties, of beds of rock formed to a large extent of the detached spicular remains of siliceous sponges, and thus distinctly of organic origin. Their true characters have not been generally recognized, and they have usually been described as deposits of sandstone, chert, malm, hearthstone, firestone, etc. In the Lower Greensand these beds are mainly developed in the lower, or Hythe, division, and they are exposed at Haslemere, Midhurst, Petworth, Godalming, Tilfurston Hill, near Godstone, Sevenoaks, Maidstone, and at Hythe. The sponge-beds vary from three-quarters of an inch to three feet in thickness; between them, as a rule, there are intervening beds of sand or sandstone. The greatest total thickness of the sponge-beds exposed in one section is eleven feet. Sponge-beds are less common in the higher or Folkestone division of the Lower Greensand, but they are numerous at Folkestone itself, and reach a total thickness of more than eight feet, and there is also a thin bed in this division at Sevenoaks. The Lower Greensand strata at Faringdon, in Berkshire, is of an altogether different character to those of the same formation in the area treated of in this paper, and the sponges which abound therein are likewise entirely different, being calcisponges, and retaining their entire forms.

The sponge-beds in the Upper Greensand are of two distinct types, one of which is shown on the northern and western margin of the Weald, and the other in the Isle of Wight, and further westward in the counties of Wilts, Somerset, Dorset, and Devon. In the first-named district the sponge-beds are of a soft greyish-white siliceous, or silico-calcareous rock, known under the names of malm, hearth, or firestone. In this the sponge-spicules principally occur in the negative form of minute empty casts, the presence of which renders the rock extremely light and porous. The beds can be traced nearly continuously along the northern and western margin of the Wealden area, and they are well shown at Godstone, Merstham, near Reigate, Betchworth, Farnham, and Selborne. Further northwards they are present at Wallingford, in Berkshire. The beds vary in thickness from 15 feet at Merstham to 60 feet at Farnham.

In the more typical Upper Greensand of the Isle of Wight and the south-western counties, the sponge-beds consist of thick layers of chert and porous siliceous rock at the summit of the series, immediately beneath the so-called chloritic marl; whilst in the lower division the sponge-remains principally occur in loose quartzitic sands with siliceous accretions. The chert or sponge-beds at the top of the Upper Greensand are best exposed at Shanklin, Ventnor, and the Undercliff, in the Isle of Wight, at Warminster in Wiltshire, and Penzlewood in Somersetshire. They vary from 10 to 25 feet in thickness. The sponge-beds of the lower division are scarcely recognizable in the Isle of Wight, but they attain a thickness of 10 to 20 feet on the summit of the Blackdown and Haldon Hills in Devonshire, and at Axmouth in Dorsetshire. The chert here is only present in beds of subordinate importance.

Sponge-beds of similar characters to those of the Greensand have been described from the Hilsandstein in Westphalia, which is of Neocomian age, and, judging from specimens which I have examined, the "Guize de l'Argonne," which is largely developed in the Ardennes, and the "Meule de Bracquegnies" in Belgium, are sponge-beds, filled with spicules and spicular casts like those of the Greensand.

The sponge-remains in the various beds are exclusively those of siliceous sponges. In some the silica of the spicules yet retains its original colloidal condition, in which it is negative to polarized light and readily soluble in caustic potash. The matrix of the sponge-beds of the malm and firestone is also to a large extent of colloidal or amorphous silica, and this material has been deposited in the form of minute globules or disks, and seems to have been derived from the sponge-spicules, with the empty casts of which the beds are throughout filled.

More generally the original amorphous silica of the sponge-remains has been altered to chalcedony, and the chert and porous siliceous rock accompanying it, which is filled with traces of the spicules, are likewise of chalcedony; occasionally the chalcedony gives place to crystalline silica.

Glauconite very commonly fills the canals of the spicules, and remains after the spicular walls have been removed, it also replaces the spicular walls.

In some sponge-beds the spicules have been nearly entirely replaced by crystalline calcite; they are embedded in a matrix of granular limestone.

As a general rule the sponge-spicules are inclosed in a compact matrix in which their forms can only be partially studied, but under certain conditions they are loosely distributed in sand, or in fine powder in cavities in chert, from whence they can be obtained quite free from matrix. The sponge-beds appear to be wholly composed of detached, free, spicules; entire sponges are absent. These spicules belong to numerous species. All four orders of siliceous sponges are represented, but those of Monactinella and Hexactinella sponges form but a small proportion, while those of Tetractinella and Lithistid sponges, more particularly of the Megamorina family, are extremely abundant.

II.—Geological Society of London.

I.—May 13, 1885.—Prof. T. G. Bonney, D.Sc., LL.D. F.R.S., President, in the Chair.—The following communications were read:

1. "On the Ostracoda of the Purbeck Formation; with Notes on the Wealden Species." By Prof. T. Rupert Jones, F.R.S., F.G.S.

The author stated that in 1850 Prof. Edward Forbes had determined the tripartite division of the Purbeck beds, after working at the sections in the south of England with Mr. Bristow, and had intimated that several species of the so-called "Cypridæ" aided him in arriving at this result. He did not, however, publish any account of the several forms, and we know of his intended species only (1) by his having pointed them out to his friends Messrs. Bristow, Osmond Fisher, and W. Cunnington; (2) by a letter to Mr. Bristow in 1851 and one to the author in 1854; (3) by some diagrams in the Museum of Practical Geology; and (4) by some rough woodcuts in Sir Charles Lyell's 'Manual of Elementary Geology,' 5th edition (1855). Having a large collection of Purbeck and Wealden Entomostraca, the author has endeavoured to decide which were E. Forbes's species; and from a careful examination of the collections in the Geological Society's Museum, the Museum of Practical Geology, and the British Museum, in which he has been greatly assisted by Mr. E. T. Newton, F.G.S., and Mr. C. D. Sherborn, he has arrived at the definite conclusion that there are fourteen species in E. Forbes's three divisions of the Purbeck series. Five of them (*Cypris purbeckensis*, *Candona bononiensis*, *C. ansata*, *Cythere Blakei*, and *C. retirugata*) occur only in the Lower Purbeck; and of the others, six occur in both the Middle and Upper. Of the fourteen, five (*Cypridea valdensis*, very rare in the Purbeck, *C. tuberculata*, *C. Dunkeri*, *Cyprione Bristovii*, and *Darwinella leguminella*) go up into the Wealden from the Middle and Upper divisions only. *Cypridea punctata* for the Upper, *C. granulosa* (*fasciculata*) for the Middle, and *Cypris purbeckensis* for the Lower Purbeck, seem to be always characteristic.

2. "Evidence of the Action of Land-ice at Great Crosby, Lancashire." By T. Mellard Reade, Esq., F.R.S.

The author pointed out that the Triassic rocks under the Low-level Boulder-clay in the neighbourhood of Liverpool, where they are not smoothed and striated, are usually broken up into rubble and red sand, forming a bed of variable thickness occasionally consolidated into a breccia. This deposit he had in former papers attributed to the action of land-ice. At Mowbrey brick-and-tile works, Great Crosby, is a section of Keuper marls, the only one existing for many miles around. The marls are overlain by Low-level Boulder-clay of the usual type, and between it and the marl is a deposit from 3 to 4 feet thick, which at first sight is not readily distinguishable from the marls, but which a careful examination of the excavations from time to time as they progressed, showed to be a distinct bed. In this bed, lying at all angles, were found large blocks of sandstone, some of which were grooved and striated in an unmistakable manner. The matrix in which they were imbedded was of the same constitution as the marl, and evidently formed out of it, showing in places strong evidence of contortion and kneading up. The sandstone blocks belonged to the Keuper formation, and some of them were very similar to bands intercalated in the marls near the bottom of the excavation. No erratic pebbles or boulders of any sort were found in this kneaded up marl, whereas the Low-level Boulder-clay is full of them.

The author considered that the only feasible explanation of the phenomenon was that the marl had been worked up into a grey clay by the passage over it of land-ice, which had broken off the sandstone-bands at their outcrops, forcing the blocks into the disturbed or worked-up marl. These outcrops, concealed by a mantle of Low-level Boulder-clay, must be to the northward, and therefore the blocks have travelled in the same direction approximately as the track of the striations on the neighbouring rocks.

In conclusion, he contended that all the evidence points to the fact before insisted upon, that the intensest period of cold preceded the deposition of the Low-level Boulder-Clay, which is clearly a marine deposit.

3. "The North-Wales and Shrewsbury Coal-fields." By D. C. Davies, Esq., F.G.S.

After discussing the origin of Coal-beds, and the causes of their variation in structure and quality, the author proceeded to describe the North Wales and Shrewsbury Coal-field, which consists of three parts:—(1) The Shrewsbury field south of the Severn, exclusively composed of Upper Coal-measures; (2) the tracts north of the Severn, extending from near Oswestry to north of Wrexham; and (3) the Flintshire Coal-field. The first and second are separated from each other by the alluvial plain of the Severn and Vyrmoy, and the second and third by the Great Bala and Yule faults.

Some remarks on the scenery of the Welsh border-land followed, and then a general section of the Carboniferous system, as developed in the country described, was given, the Permian beds being included, as the author considered them the upper portion of one great division of Palæozoic time. The section was as follows, with the maximum thickness of each subdivision:—

	Thickness in yards.	
1. Dark red Sandstone	210	Permian, 590 yards.
2. Ifton or St. Martin's Coal-measures..	75	
3. Red marls with calcareous matter ..	180	
4. Green rocks and Conglomerates	125	
5. Upper Coal-measures	80	Coal-measures, 665 yards.
6. Cefn rock to Cefn coal	100	
7. Cefn coal to Lower yard-coal	270	
8. Lower yard-coal to Chwarcle coal ..	80	
9. Chwarcle coal to Millstone Grit	135	
	1255 yards.	

A detailed description of the strata was next given, beginning with the lowest, together with details of each coal-seam as worked in various parts of the field. After describing the beds from the Millstone Grit to the Cefn rock in the North Wales coal-field, the author proceeded to notice the Upper Coal-measures and Permian strata in the Shrewsbury area, and showed that no break exists between the two, the former passing gradually into the latter. He then discussed the probability of Lower Coal-measures existing beneath the upper beds near Shrewsbury, and showed from sections that the existence of the lower measures might be anticipated. A similar inquiry as to the presence of the Coal-measures beneath the New Red Sandstone of the Vale of Clwyd should also, in the author's opinion, be answered in the affirmative.

The organic remains found in the different beds were briefly noticed, and then the faults of the district were discussed at some length. The principal faults run north and south, with an upthrow to the east, but are crossed by lines of fracture running east and west.

In conclusion, the correlation of the strata in the North Wales and Shrewsbury coal-fields, and especially of the coal-seams, with the beds found in other parts of Great Britain, was discussed, and a section was given to show the representation of the different measures in various coal-basins. The author was disposed to adopt four subdivisions rather than three only, as usually accepted, and pointed out some of the characteristics of each subdivision.

II.—May 27, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On the so-called Diorite of Little Knott (Cumberland), with further Remarks on the Occurrence of Picrites in Wales." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., Pres.G.S.

The Little Knott rock and its microscopic structure were briefly described by the late Mr. Clifton Ward, who named it a diorite, but called attention to its abnormal character. The author gave some additional particulars, and showed that although the rock varies in different parts of the same outcrop, and is not one of the most typical representatives of the picrite group, its relations on the whole are with this rather than with the true diorites. He also called attention to the extraordinary number of boulders which have been furnished by this comparatively small outcrop, and discussed the relation of their distribution to the former extension and effects of ice in the Lake District. He briefly noticed the occurrence of additional boulders of picrite in Anglesey, and described specimens from two localities (Caemawr and Pengorphwysfa) where a similar rock has been discovered *in situ* by Professor Hughes. Hence it is probable that the Anglesey boulders are derived from localities in that island, and not from Cumberland. From a re-examination of specimens collected by the late Professor Sedgwick and Mr. Tawney, preserved in the Woodwardian Museum at Cambridge, the author showed that the rock must occur *in situ* in two localities in the Lleyn peninsula, in the neighbourhood of Clynnog and of Aberdaron. Lastly, he described a very remarkable picrite boulder, discovered by Dr. Hicks, which rests on "Dimetian" rock at Porthlisky near St. Davids.

2. "Sketches of South-African Geology.—No. 2. A Sketch of the Gold-Fields of the Transvaal, South Africa." By W. H. Penning, Esq., F.G.S.

The Gold-Fields of the Transvaal have been defined as covering nearly all the eastern and northern districts of the State, though but a small portion of the area is productive. In this paper the author described only the Lydenburg and De Kaap gold-fields, leaving those of Pretoria and Marabastadt for a future communication. The auriferous region is known to extend 350 miles to the northward beyond the Limpopo river, so that the gold-bearing rocks are found throughout at least 7½ degrees of latitude and 3 of longitude.

The area of the two gold-fields mentioned, comprising together about 3000 square miles, was defined; and the author, after noticing some old gold-workings, proceeded to give an account of the physical features of the country. He especially called attention to the circumstance that most of the rivers rise to the west of the highest range, and flow eastward through it.

The oldest gold-bearing rocks consist of unfossiliferous schists, shales, cherts, and quartzites, classed by the author as Silurian. Amongst these a great mass of coarse granitic rock is intruded, consisting of quartz and felspar, with but little, if any, mica. This granite, in the De Kaap valley, forms an ellipse 17 miles long by 10 broad, with a narrow northerly prolongation. Both the granite and the stratified rock are traversed by intrusive dykes, chiefly of diorite.

These beds have been much disturbed, and then cut down, probably by marine denudation, to a level plain 1700 or 1800 feet above the sea. Upon them rest unconformably a great sequence of conglomerates, sandstones, and shales, the "Megaliesberg beds" of a former paper, but now provisionally classed as Devonian. These rocks also are traversed by dykes of diorite and other kinds of trap. The "High Veldt beds" overlie the "Devonian" with some unconformity.

Several sections and observations illustrative of these facts were described, and details were given of the different gold-mines in each of the great systems noticed, and also in alluvial deposits. It was shown that much gold was derived originally from veins in the older or Silurian rocks, and that some of that met with in the newer system occurred in conglomerates or other detrital beds. But there are also gold-bearing quartz-veins intersecting the latter.

3. "On some Erratics in the Boulder-clay of Cheshire, etc., and the Conditions of Climate they denote." By Charles Ricketts, M.D., F.G.S.

The author stated that the glacial phenomena of the valley of the Mersey indicate that the country has been entirely covered with ice and snow, resulting solely from the snowfall on its water-slopes and those of the tributary valleys. The glacial striæ coincide in direction with that of the respective valleys, or are in direct connexion with the contour of the ground. The bottoms of the valleys are usually filled to some extent with irregularly stratified sands and gravels, containing erratic pebbles from which all striæ have been removed, probably by currents of water holding sand in suspension. Above these there is a boulder-clay containing a larger proportion of sand and gravel than the boulder-clay proper. The flanks of the valleys are covered with unstratified sand or fragments of sandstone derived from the Trias, probably left by glaciers as submarine moraines. The whole is overlain by the true boulder-clay, an unstratified reddish-brown clay containing erratics derived from different and distant localities. This clay originated in the grinding-action of the glaciers upon the neighbouring rocks, and was carried out in the form of mud by subglacial streams of water. The contained pebbles, many of which are smoothed, flattened, scratched, and striated, were carried by and dropped from icebergs and floating ice; they are so abundant as to indicate that the bay of Liverpool was densely packed with ice.

The author noticed the occurrence in these beds of masses of contemporaneous sands, gravels, etc., caused by changes in the extension of the glaciers, and described a large series of erratics derived from granitic, volcanic, Silurian, Carboniferous, and other rocks covered with striæ and other glacial markings, and also affording evidence of subsequent exposure to weathering before they were floated away and dropped into the clay. In connexion with this weathering of the boulders, the author remarked that in the case of the granitic and volcanic rocks, the process differed greatly in degree, extending in some granites to the separation of each individual grain throughout the whole mass, and he called attention to the occurrence in Ireland of fragments of disintegrated granite and trap imbedded in moraines, eskers, and Boulder-clay, and to that of Wastdale-Crag granite similarly decomposed in the moraines in the neighbourhood of Shap, where also rocks of volcanic origin have become weathered in the same way as some in the Boulder-clay of Cheshire. Fragments of limestone also show traces of erosion, while others have been split into two or more pieces since their glaciation, phenomena also observed in moraine-accumulations in limestone-districts. Similar phenomena occur in the case of slaty and other stratified rocks. Some limestone pebbles have been perforated by Mollusca and other marine animals.

The inference drawn by the author from the facts recorded in his paper is that these weathered boulders once formed portions of moraines on land from which, for a time, the glaciers had receded, and that, after a succession of seasons sufficient to disintegrate these blocks more or less, an increased snowfall caused such an extension of the glaciers that the blocks were carried down to the sea and conveyed away in icebergs and by floating ice to the spots where they are now imbedded. As they occur at different horizons, there must have been a repetition of the advance and retreat of the glaciers, such as now occurs in Greenland.

III.—June 10, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "Note on the Sternal Apparatus in *Iguanodon.*" By J. W. Hulke, Esq., F.R.S., V.P.G.S.

The author remarked that although parts of the pectoral arch of *Iguanodon* had been identified in this country and in Belgium, nothing definite was known of the structure of the sternum itself, and stated that a specimen in the collection of Mr. Beckles, from the Wealden of Hastings, seemed to throw some light upon this point. The specimen in question consists of an azygos bar, from near one end of which two smaller rods diverge laterally, the latter terminating mesially in expanded ends, applied to what the author regarded as the ventral surface of the azygos bar, where they approach each other very closely. These two diverging bones are regarded by the author as the clavicles. All the evidence tends to show that the parts are in their normal relations, in which case the clavicles bear the same relation to the interclavicle as in the pectoral arch of existing Lacertilia.

The azygos piece is a long flattened bar, widening posteriorly for some distance from the attachment of the clavicles, and then narrowing slightly to the posterior extremity. The lateral borders from the clavicles to the widest part are smooth and gently arcuate for the articulation of the epicoracoid; behind this they are rough and apparently non-articular. The author discussed the nature of the azygos piece, which evidently includes the interclavicle; but whether it comprises the costal sternum is questionable. There are no indications of the connexion of ribs with its lateral borders, and its figure is quite unlike that of the sternum in existing Lacertilia and Crocodilia. From all its characters the author concluded that the azygos piece represents only the interclavicle, and he suggested that the costal sternum may have been cartilaginous, as in existing Crocodiles.

2. "The Lower Palæozoic Rocks of the neighbourhood of Haverfordwest." By J. E. Marr, Esq., M.A., F.G.S., and T. Roberts, Esq., B.A., F.G.S.

The authors in this communication described the sequence of the Lower Palæozoic rocks lying to the north of Haverfordwest and Narberth. Their work is founded on that published by the Geological Surveyors in their maps, sections and memoirs.

To the north of the ridge of rock running eastward from Rock Castle, claimed as Archæan by Dr. Hicks, they have discovered Lingula Flags, with *Olenus spinulosus*, Wahl, and *Agnostus pisiformis*, Linn. These beds are seen underlain by conglomerate, resting upon older rocks, near Trefgarn Bridge.

South of Dr. Hicks's Archæan ridge, a great fault brings beds of Bala age in juxtaposition with the rocks of the ridge; hence, in the tract described, no rocks of Tremadoc and true Arenig age have been met with. In the area south of the ridge the rocks are thrown into a complex synclinal, with a complex anticlinal to the south-east, near the town of Narberth.

The succession which the authors attempted to establish in this area is as follows (in ascending sequence):—

i. *Didymograptus* shales, with *Murchisoni*-form Graptolites.

ii. Llandeilo limestone, with *Asaphus tyrannus*, Murch., etc.

iii. *Dicranograptus* shales, with *Dicranograptus*, *Climacograptus bicornis*, *Diplograptus foliaceus*, etc., having a zone at the summit marked by the abundance of *Orthis argentea*, His.

iv. Robeston Wathen Limestone, with many Corals and Brachiopods, and few Trilobites.

v. *Trinucleus-seticornis* beds, characterized by abundance of *Trinucleus seticornis*, His., and its variety *T. Bucklandi*. These are subdivided into three stages, viz.:—(*a*) Sholeshook limestone, with Cystideans and an abundant Trilobite fauna, including *Agnostus trinodus*, Salt., *Trinucleus seticornis*, His., *Stygina latifrons*, Portl., *Phillipsia parabola*, Barr., *Cheirurus parvus*, Salt., *Encrinurus sexcostatus*, Salt., *Phacops Brongniarti*, Portl., etc.

(*b*) Redhill beds, blue-grey shales, generally poor in fossils, but containing here and there a fair abundance, especially of *Phacops Brongniarti*, Portl., and *Trinucleus Bucklandi*, Barr., and many Lamellibranchs and Gasteropods.

(*c*) Slade beds, consisting of gritty green shales with calcareous bands crowded with fossils. *Glauconome disticha*, *Phyllopora Hisingeri*, M'Coy, *Phacops Brongniarti*, Portl., *Trinucleus seticornis*, His., *Calymene trinucleina*, Linns., *Orthis testudinaria*, Dalm., are abundant. *Climacograptus*, sp., also occurs.

vi. Conglomerate, containing many quartz pebbles, succeeds the beds of the Slade stage in many localities, and does not seem to mark a great discordance, as the authors have nowhere found it resting on lower beds.

vii. Lower Llandovery beds. Green gritty shales, with grit and very fossiliferous calcareous bands, characterized especially by *Nidulites favus*, *Petraia subduplicata*, var. *crenulata*, *Stricklandinia lirata*, etc., and containing *Phacops elegans*, Bœck and Sars, *Phacops mucronatus*, Ang., and *Deiphon Forbesi*, Barr.

The authors attempted a correlation of the Haverfordwest rocks with those of other areas:—

Conglomerate and grit of Trefgarn	=Harlech ?
Lingula Flags of Trefgarn, etc.	=Dolgelly beds.
Didymograptus shales	=Llanvirn.

Llandeilo Limestone =Lower Bala.
Dicranograptus shales =Lower and Middle Bala.
Robeston Wathen Limestone =Bala Limestone.
Trinucleus-seticornis beds =Upper Bala.
Conglomerate
Fossiliferous Lower Llandovery beds } =Lower May Hill.

In conclusion the authors notice two points which require further elucidation. The first is the separation of the Robeston Wathen and Sholeshook limestone. This is made on palæontological and lithological grounds, as the whole thickness of the two limestones had nowhere been met with in the same section. The second is the relationship of the conglomerate to the fossiliferous Lower Llandovery beds. In the only place where the two appear in justaposition the conglomerate series appear to underlie the fossiliferous Llandovery beds; this the authors explained by a faulted overfold. These difficulties do not, however, prevent the authors from hoping that the sequence they have established will be of use in assisting to determine the character of the very remarkable folds by which the district has been affected.

3. "On certain Fossiliferous Nodules and Fragments of Hæmatite (sometimes Magnetite) from the (so-called) Permian Breccias of Leicestershire and South Derbyshire." By W. S. Gresley, Esq., F.G.S.

In this paper the author described certain pebbles of hæmatite and magnetite which occur in the so-called Permian breccias on the western margin of the Ashby-de-la-Zouch Coal-field. These pebbles, which are largely collected for sale and used as "burnishers," vary in size from a diameter of $\frac{1}{16}$ inch to the size of a man's fist. They present many varieties of form, have sometimes an agate-like structure, and occasionally exhibit well-marked magnetic polarity. Sometimes they show grooving and striation resembling those produced by ice-action, while at other times they seem to have been crushed and recemented. Many of these pebbles contain fossils of various kinds, chiefly plant- and insect-remains, but with a few of Annelids, Mollusca and Fish. All the fossils are of Carboniferous age.

From the consideration of all the facts detailed in the paper, the author concluded that these nodules were originally composed of clay ironstone, and that they were derived from Carboniferous strata. He considered that the pseudomorphic action by which they have acquired their present composition must have taken place *in situ* since their inclusion in the breccia.

III.—The Geologists' Association.

At a meeting held at University College, on the 5th June last, Mr. Herbert Goss, F.L.S., F.G.S., etc., read a paper "On Some recently-discovered Insecta and Arachnida from Carboniferous and Silurian Rocks." After remarking on the great number of Palæozoic Insects lately discovered, and calling attention to the recent investigations and writings on the subject of M. Charles Brongniart, Mr. Scudder, Dr. Deichmüller, Dr. Dohrn, Dr. Fritsch, Dr. Eugen Geinitz, Dr. H. B. Geinitz, Dr. Goldenberg, Dr. Hagen, Professor Lindström, Dr. Nóvak, Mr. B. N. Peach, Dr. Sterzel, and others, the author stated that at the date of his last paper (March, 1879), only 103 fossil insects from the Carboniferous rocks of the whole world were known; but that during the last five years a large number had been discovered, including about 1400 from the Coal-measures of Commentry, France; a few from Saarbrück, Klein Opitz, Lugau, and elsewhere in Germany; and a considerable number from various parts of the North American continent. Such of the specimens as had yet been determined were then enumerated, some of the most remarkable forms were referred to in detail, and attention was drawn to their affinities with existing types. According to M. Brongniart the Commentry fossils included about 40 types, some of which appeared allied to representatives of existing genera of *Hemiptera, Neuroptera, Pseudo-Neuroptera,* and *Orthoptera.* On the other hand, many of these fossils apparently belonged to some synthetic or homogeneous types, uniting in themselves characteristics of *Neuroptera* and *Orthoptera,* or *Neuroptera* and *Hemiptera,* and proving that at this early period the differentiation of most of the existing groups had hardly commenced.

Attention was then called to the discovery, last year, of fossil Scorpions in the Upper Silurian of the Isle of Gotland and Scotland, and of the wing of a Cockroach in the Middle Silurian of Jurques Calvados, France. Prior to these discoveries, no remains of terrestrial animals had been obtained from any strata older than the Devonian, and the result of their discovery in Silurian strata was to leave the Insects the oldest known class of land animals, and the Cockroaches the oldest known family of insects.

The paper concluded with a summary of the results of recent discoveries, and it was stated that the evidence afforded by Palæontology was, as far as it went, in support of the views as to the origin of insects, and the order of succession on the earth of the various groups, arrived at by Dr. Packard and others from a study of the embryology of the class. No evidence had however yet been obtained of the existence of any earlier forms connecting the Insecta with those lower groups from which they are believed to have originated.

CORRESPONDENCE.

THE ENSTATITIC LAVAS OF EYCOTT HILL.

Sir,—Mr. F. Rutley, in his letter on the "Enstatitic Lavas of Eycott Hill," is not quite correct in some of his statements. He asserts that when the late Mr. Clifton Ward wrote his Memoir on the Geology of the northern part of the Lake District, the name Andesite was not in use except as a synonym for andesine felspar. To this I demur—the rock, for instance, is described in my edition of Zirkel's *Mikroscopische Beschaffenheit,* which is dated 1873, my copy of the Memoir being dated 1876. It is even mentioned in Lawrance's translation of Cotta (1866). Further, I remember pointing out to Mr. Ward, when first he used the term *felsidolerite* (a term of barbarous etymology and self-contradictory), that the more acid lavas of the Lake District agreed with some porphyrites, and only differed from andesites by slight mineral changes.

Again, the rhombic pyroxene which I have described in the Eycott Hill rock (which I leave among the *basalts*) differs in some respects from that described by Messrs. Cross, Iddings, and Teall, and (as may be seen from my paper) is more nearly related to the mineral which occurs in certain peridotites and serpentines. As I went in 1876 to examine a rock containing it, I presume it was pretty well known some years previously, It was, however, very natural that Mr. Ward should overlook this mineral—indeed, a characteristic specimen may not have occurred in the slide or slides which he examined. This, however, seems so obvious a truism that the only motive which I can understand in Mr. Rutley's letter is to hint obliquely that I have not done Mr. Ward full justice. This I maintain is not warranted by anything in my paper. No one can regard the memory of Mr. Clifton Ward more highly than I do, for I continue to regret him as a near and dear friend, no less than I esteemed him as a geologist. But I did not and do not consider that I was bound to preface my paper by some apologetic remarks for venturing to correct slightly and add a little to what he had written on the subject. If we, whose lives are spared, are not to endeavour in our humble way to advance knowledge, for what are we living?

T. G. Bonney.

SUBTERRANEAN CONTOURING ON GEOLOGICAL MAPS.

Sir,—In the May Number of the Geological Magazine, received yesterday, a Correspondent of yours asks me: "How the position for contours [of Rock Beds] may be accurately ascertained at depths far removed from observation, amongst highly contorted or disturbed strata?" Really I know of no method but digging; yet it sometimes happens even in such extreme cases that an opinion of more or less value can be formed by means of a careful instrumental survey.

What I maintain is that contour lines enable any such opinion to be expressed clearly and precisely, of course the mode of expression does not by its clearness and precision increase the certainty or truthfulness of what is expressed. Nor are opinions necessarily valueless because not certain beyond a doubt; nor are all opinions to be called mere "fancies." If geological maps could literally only give what has actually been observed on the surface, they would generally be barren indeed and leave almost as much to the intelligence of the reader as the unexplored ground does. The aim of geological surveys is to ascertain the probabilities in regard to what is hidden; and in easy cases and thorough surveys the probabilities perceived by the geologist are sometimes practically as good as certainties; in many other cases the indication with precision of the probable, not "merely possible, position" of a rock bed under cover is of the highest importance. Clearly the degree of probability ought not to be exaggerated. But precision is in itself no such exaggeration.

The very necessity of stating an opinion precisely and definitely, if at all, and of making it correspond throughout with all the surface facts so far as they have been observed, is a great incentive to careful thoroughness; and the work specially required for underground contours, both in the field and in the office, gives much more than ordinary value to a geological survey.

He asks further: "Whether I would advise the use of distinct plans on which to record the positions of the contours at the various depths, when ascertained." Of course the various depths can have each but one contour line, and naturally I would not recommend a separate map for every contour line: but perhaps some misprint or other slip has concealed the drift of the question.

NORTHAMPTON, MASS., 20 *May*, 1885. BENJ. SMITH LYMAN.

THE CLASSIFICATION OF THE JURASSIC SYSTEM.

SIR,—I had not intended to trouble you with any further remarks on this subject, but as part of Dr. Blanford's last letter has been repeated in the June Number of the MAGAZINE for the sake of correcting a typographical error, I may be allowed to answer the paragraph so reprinted.

I think Dr. Blanford fails to apprehend the object of my reference to the Lower Calcareous Grit. It was this,—he proposes to place the Coral Rag in the upper division and the Oxford Clay in the middle division of the Jurassic system; I reply that the lower member of the Coral Rag is so closely connected by its fossils with the Oxford Clay, that it would be unphilosophical to draw such an important line of separation below it.

I do not see what the Callovian has to do with this argument, but I had certainly not forgotten its existence, for I happened to mention it in my first letter (GEOL. MAG. 1884, p. 525) as forming the base of the Oxfordian.

My argument is simply this, that there is a greater palæontological change in passing from the Cornbrash to the Oxfordian than there is between the Oxfordian and the Coral Rag. The question of the lithological change is not worth further discussion; I quite admit that the point should be decided on palæontological grounds, but I do not agree with Dr. Blanford's method of handling the facts.

June 6th, 1885. A. J. JUKES-BROWNE.

THE DARWIN MEMORIAL STATUE, the execution of which, in white marble, had been entrusted to Mr. Boehm, was unveiled by H. R. H. the Prince of Wales at the British Museum (Natural History), Cromwell Road, on Tuesday, 9th June, 1885, when Prof. Huxley, President of the Royal Society, delivered an address on behalf of the Darwin Memorial Committee, and handed over the care of the statue to the Trustees. The Prince of Wales replied on their behalf. The Archbishop of Canterbury and many other of the Trustees were present, and a large assemblage of scientific men and friends and admirers of Darwin filled the Great Hall.

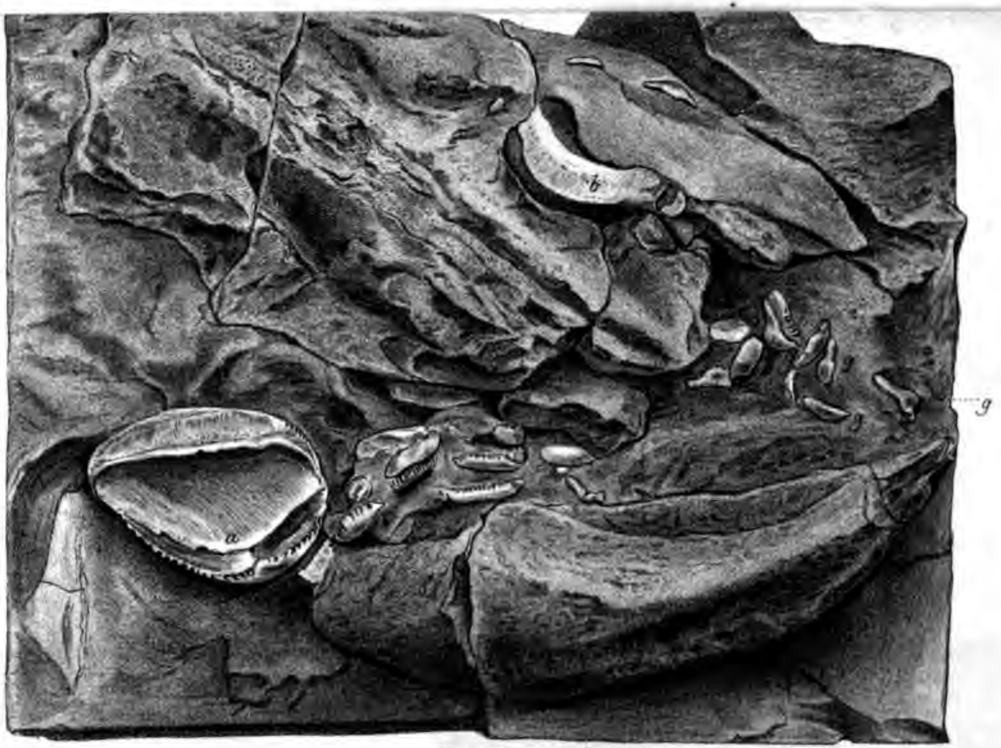

Fig. 1.

From Nature by R. H. Traquair, M.D.

M'Farlane & Erskine

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No. VIII.—AUGUST, 1885.

ORIGINAL ARTICLES.

◆

I.—On a Specimen of *Psephodus magnus*, Agassiz, from the Carboniferous Limestone of East Kilbride, Lanarkshire.[1]

By R. H. Traquair, M.D., F.R.S., F.G.S.

(PLATE VIII.)

IN his "Tableau générale des Poissons Fossiles," published in 1844, and appended to the first volume of his great work, Agassiz enumerates five species of his Carboniferous selachian genus *Cochliodus*, of which he only described one, the well-known *C. contortus*; the others, of which the names only were then published, being *C. magnus*, *C. acutus*, *C. oblongus*, and *C. striatus*.

C. magnus was, however, figured by Lieut.-Col. Portlock in his "Geological Report of Londonderry and parts of Tyrone and Fermanagh" (pl. 14a., fig. 4). It is a large, broadly oblong convex crushing tooth, with crenulated edges, common at Armagh, in Ireland, and not at all rare in the Carboniferous Limestone of many localities in Scotland. In the same work (p. 462) Col. Portlock quotes a letter from Captain Jones, in which that gentleman, a zealous collector of fossils from the Armagh limestone, expresses the opinion that this tooth passes into *Helodus planus*, another Armagh species, named but not described by Agassiz.

Both *Cochliodus magnus* and *Helodus planus* were described, and the latter also figured, by M'Coy, who still retained them as belonging to separate genera and species, for though he mentions Captain Jones's opinion regarding them, he states that he himself had not seen the passage. As regards *C. magnus*, M'Coy assigned three teeth to each ramus of the jaw, so as to form an arrangement corresponding with that in *C. contortus*. He also doubted the position of the species in the genus *Cochliodus*, on account of the slight enrolment, the little definition of the characteristic oblique ridges, and the strong crenulation of the edges.[2]

Agassiz, having visited Great Britain again in 1859, extensively revised the names of the Carboniferous selachian remains in the magnificent collection of the Earl of Enniskillen, at Florence Court, in Ireland, and instituted a great number of new generic and specific names, involving in many cases considerable subdivision of former genera. A list of these MS. names was supplied by

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[1] Reprinted from the Transactions of the Geological Society of Glasgow, vol. vii. part 2, pp. 392-402, pl. xvi. Glasgow, July, 1885.

[2] "British Palæozoic Fossils," London and Cambridge, 1855.

Lord Enniskillen to Messrs. Morris and Roberts, and published by them in the Quart. Journ. of the Geological Society, vol. xviii. 1862, pp. 99–102. From this list it appears that out of the previously quoted species of *Cochliodus*, except the first, *C. contortus*, a number of new genera, as well as several additional species, were established. *Cochliodus magnus* from Armagh became *Psephodus magnus*, with which *Helodus planus* was merged; *C. magnus* from Bristol became *Tomodus convexus*; *C. acutus* became *Deltoptychius acutus* and *gibberulus*; *C. oblongus* became *Streblodus oblongus*, *Colei* and *Egertoni*; and lastly, for *C. striatus*, the genus *Xystrodus* was proposed.

Teeth undoubtedly generically identical with Agassiz's *Psephodus* were in 1866 figured by Messrs. Newberry and Worthen, under the name of *Aspidodus crenulatus*.[1] The authors refer to the resemblance which these teeth bear to Agassiz's *Cochliodus magnus*, and suggest that the latter, as well as *Helodus planus*, should be included in *Aspidodus*. In this Messrs. Newberry and Worthen would have been perfectly right had *Psephodus* been a *mere* MS. name like so many others which Agassiz left behind him at Florence Court. For though no definition of *Psephodus* appeared along with the publication of the name in 1862, its type species, *magnus*, had been sufficiently well figured and described by Portlock and M'Coy to enable naturalists throughout the world to identify the genus. We may, therefore, grant priority to Agassiz's name, though solely on the grounds above given. And in the sixth volume of the Geological Survey of Illinois the name *Aspidodus*, given by Messrs. St. John and Worthen, is relinquished in favour of *Psephodus*.

It is indeed much to be regretted that Agassiz did not himself publish figures and descriptions of the numerous genera and species of fossil fishes to which in various collections he affixed MS. names, and in hardly any department did the non-completion of his work hinder progress more than in the case of those selachian remains from the Carboniferous Limestone contained in the Florence Court collection. Many of those names given by him in his revision of 1859 became current among collectors without their having any published means of verifying their identifications, and the names themselves being MS. names still, in spite of their publication by Messrs. Morris and Roberts, were liable at any moment to be superseded. This want has, however, been supplied by Mr. J. W. Davis, who, having been entrusted by Lord Enniskillen with the task of working up the Carboniferous limestone selachian remains in his collection, last year published descriptions and figures of the genera and species there named by Agassiz, along with many others established by himself as new. The Enniskillen collection itself having been recently acquired by the British Museum, the scientific public at large have now ample opportunity of knowing the present condition of this branch of palæichthyological science, so far at least as specimens from British Carboniferous rocks are concerned.

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[1] Geological Survey, Illinois, vol. ii. p. 92.

In this work[1] Mr. Davis follows M'Coy in assigning three principal teeth to each ramus of the jaw of *Psephodus magnus*, and has given a figure representing three such teeth placed together in the position he supposed them to occupy. Admitting *Helodus planus* as a synonym, he assigns to these "Helodont" teeth a position—some in front of the larger plates, others on the palate between them.

Mr. Davis summarizes his views as follows:—"That a row of three principal teeth, increasing in size backwards, were attached to each cartilaginous ramus of the jaw; that the diameter of the jaw, as indicated by the groove or channel on the under surface of the teeth, diminished towards the symphysis; that a long narrow tooth was placed in front of the anterior one, and that a series of at least three Helodoid teeth were placed behind it, extending over the palate and increasing in size backwards." (*op. cit.* p, 47.) The following sentences may also be quoted:—"It is not probable that more than three teeth existed on each side of the jaw; and the teeth hitherto known as *Helodus planus*, Ag., occupied the intervening portion of the palate. An example (pl. lv. fig. 6) shows a Helodoid tooth to have occupied a position in front of the anterior tooth, as well as the palatal space behind." (*op. cit.* p. 441.)

These views appear, however, to be in the main hypothetical. The "three principal teeth" have not, so far as I am aware, been found together in the positions ascribed to them; nor does it seem clear what Mr. Davis means by the "intervening portion of the palate," or the "palatal space," unless he supposes these Helodont teeth to have been unsupported by the cartilaginous jaw arches, mandibular below and palato-quadrate above, which is certainly improbable. One of his figures (pl. lv. fig. 4), however, shows three of the Helodoid teeth in longitudinal apposition; another (fig. 9) two similarly related to each other, and to a broad tooth; and again (fig. 6) we have one of the narrow teeth lying alongside the trigonal one, supposed by M'Coy and himself to be "anterior."

Mr. Davis's paper was read before the Royal Dublin Society, May 15, 1882, and published during the following year. But also in the same year (1883) appeared the seventh volume of the Geological Survey of Illinois, containing extensive new researches among the Carboniferous selachian remains of that region by Messrs. St. John and Worthen, and made independently of Mr. Davis's work. In this volume a considerable share of attention is given to the genus *Psephodus*, and the results certainly do not correspond with the views of Mr. Davis. While the authors state that "in reference to the dentition of *Psephodus* our information is still meagre," they seem to have come to the conclusion that "while the median portion of the rami of the jaws of *Psephodus* was enveloped by a moderately-contorted dental plate, this plate was flanked on either side by series of teeth disposed in rows from within outwards, similar to the occurrence of the teeth upon the jaws of *Cestracion*." And as regards the allocation of the larger dental plates, one form apparently corresponding with the supposed "posterior" tooth of M'Coy and Davis is provisionally referred to the lower jaw, while another resembling the supposed "middle" tooth is in like manner referred to the upper jaw.[1] Moreover, on the 8th December, 1881, prior to the reading of Mr. Davis's paper, Mr. James Coutts exhibited before the Geological Society of Glasgow a remarkable specimen of *Psephodus magnus*, discovered by Mr. A. Patton in the shale accompanying the cement-limestone of East Kilbride, and his remarks upon it were published also in 1883.[2] In this specimen we have remains of the cartilage of the jaws, along with an aggregation of teeth, which undoubtedly belonged to the same mouth. Concerning the teeth here exhibited, Mr. Coutts remarks:—"The two largest teeth evidently belong to *Cochliodus magnus*, or, as it is now given in the 'Catalogue of Western Scottish Fossils,' *Tomodus convexus*, Agassiz. Others of the teeth agree closely in form with *Helodus planus*, now *Psephodus magnus*, Agassiz, thus confirming Captain Jones's opinion that the teeth of *Cochliodus magnus* and *Helodus planus* belong, in all probability, to the same fish. Some of the teeth in this specimen agree very closely with *Helodus mammillaris*, Agassiz, while others differ in form from any of the species indicated; indeed, it is very doubtful if there are any two teeth exactly alike, but this is a feature common to the group of fishes to which the specimen belongs." From the dates it will be seen that the remarks of Mr. Davis and Mr. Coutts, on this form, were written and published altogether independently of each other.

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[1] "On the Fossil Fishes of the Carboniferous Limestone Series," Sc. Trans. Roy. Dub. Soc. vol. i. ser. 2, 1883. (Read May 15, 1882.)

Through the kindness of Messrs. Patton and Coutts, this very interesting specimen has been entrusted to me for re-examination, and in the present communication I propose to give a more detailed description of the facts and features which it displays.

The specimen is contained on a nearly rectangular slab of shale 9½ inches in length by 4 in breadth. That which we may call the *anterior* half of the surface (Pl. VIII. Fig. 1) is occupied by remains of cephalic cartilage, with teeth, behind which, on the posterior half, we find some obscure remains of a vertebral column. The most prominent object which strikes the eye on the anterior part of the slab, and lying close to what may, for convenience, be called the lower margin, is a piece of calcified cartilage, 3½ inches in length, of an elongated form, gently curved, and broader behind than in front, which one feels much tempted to regard as the ramus of a jaw. Close to and slightly above the hinder extremity of this cartilage is one of the large dental plates of *Psephodus magnus* (*a*), lying with its deep or concave surface upwards; but it may be lifted from the matrix and freely examined on all sides. This dental plate (seen isolated and from the convex surface in Fig. 3) is one of those trapezoidal teeth, considered as "middle" by M'Coy. All its margins are crenulated, save the so-called inner margin, with which very distinct lines of growth run parallel.

In front of this tooth, and extending to the anterior margin of the slab, are seen many irregularly placed small Helodont teeth, above hich again the surface is mainly covered by calcified cartilage, ırough which (at *b*) the broken margin of another large tooth may ɜ seen projecting. A fracture enables us to raise this cartilaginous ɔrtion of the specimen, bringing into view upon its under surface Fig. 2) a large number of additional teeth, among which is the large ıe whose broken edge I have already alluded to. This is firmly ₓed to a stout long-shaped piece of cartilage, resembling a jaw ımus, which is not, however, preserved in its entirety, being ›liquely broken off in front. The tooth itself (Fig. 4) belongs to ıe category reckoned by M'Coy and Davis as the "posterior" tooth ˸ *Psephodus magnus*, and of this it represents one of the rude ›nvex varieties. The margin regarded by M'Coy as "inner" is roken away; the anterior and posterior margins are crenulated; ıe so-called "outer" bent margin is entire and smooth.

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[1] p. 64.

[2] Trans. Geol. Soc. Glasgow, vol. vii. pt. i. pp. 164–166.

These two teeth, above described, are the only large ones seen in ıe specimen. They undoubtedly belong to *Psephodus magnus*, gassiz, and not to *Tomodus convexus*, as stated by Mr. Coutts; but s mistake is readily excusable when we consider the difficulty and, many cases, impossibility, of identifying Agassiz's MS. genera, ıtil the appearance of Mr. Davis's work.

There are no less than forty-four smaller teeth exhibited in the ›ecimen. Mr. Coutts mentions thirty-two, including the two large ıes; but by careful working out I have been able to uncover the lditional number. They are mostly rather confused in position; ıt as seen in Fig. 2, several groups occur of two, three, and four in ›position. The most posterior of these smaller teeth (*c*) is isolated om the rest, and somewhat resembles *Helodus rudis* of M'Coy, ough smaller in size. It is oval in shape, ½ inch in length by in breadth, slightly convex on the surface, and with its margin oping and crenulated.

More than twelve of the teeth (*d*) in front of this and lying ›tween the two larger ones are clearly identifiable with *Helodus anus*, though they exhibit considerable variety in size as well as ıape; the largest being nearly one inch, the smallest ⅜ inch in ngth. Some of them are much broader behind than in front, with ›lique posterior margins, others are more rectangular; some exhibit ›nsiderable lateral convexity of the crown, on others the surface is ore flattened; in all, the margins are crenulated.

Closely behind the large tooth (*b*) may be observed four teeth of peculiar form (*e*), three of them being in apposition. The largest these is $\frac{6}{12}$ inch in length by ⅛ in breadth; the shape somewhat ctangular, but from the middle of one margin a small angular ›int projects over the tooth next in advance. The margins are enulated.

The remaining teeth are placed in advance of those already scribed, and most of them, where their shape is clearly exhibited, esent the characters of Romanowski's genus *Lophodus*,—a genus stituted for those Helodont teeth which possess a well-marked, ›re or less compressed, and vertically striated or crenulated root.[1]

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[1] Bull. Soc. Imp. Nat. Moscow, vol. xxxvii. 1864, pp. 157–170.

Among these considerable variety of form may be observed. One at least (*f*) is referable to *L. didymus*, Ag. sp., showing a broad prominent central elevation or boss, which "posteriorly" is distinctly divided into two smaller ones, below which and close to the margin of the crown is a small angular prominence. Though the division of the central elevation of the crown is feebly indicated in at least one of the others, in the rest it disappears, and the teeth assume the characters of *L. lævissimus*, Ag. sp. (*g*); finally, all definition of the boss ceases, the crown ultimately becoming nearly flat. In some of these "*lævissimus*" forms the boss is markedly unsymmetrical, being much more sharply defined on one side than on the other.

Concerning the rest of the specimen not much is to be said. Immediately behind the large tooth (*a*) there is a flat piece of osseous matter $\frac{11}{12}$ inch in length by ⅛ in breadth, concerning which I am unable to offer any opinion. The remains of the vertebral column, of which a length of three inches is preserved, are limited to a set of elongated closely-placed spinous processes, which are, however, very obscurely seen; there is no trace of vertebral bodies, so that, as might be expected in a Palæozoic Selachian, the notochord must have been persistent. One or two minute, sharply-ridged, shagreen bodies may also be observed.

Observations.—Although the above-described specimen is one of great importance for Carboniferous Selachology, our first reflection must be that we are far from having the entire dentition of the fish before us, and that a considerable portion of the specimen must have been lost. It is very improbable that the species possessed less than four of the large tooth plates—one on each side above and below—but were only one pair present the two would be symmetrical with each other. Here we have two of these plates present, belonging respectively to the forms supposed by M'Coy and Davis to be the first and second tooth of a cochliodont dentition, but the mode in which they occur lends no support whatever to that theory. Much more probable does it seem to me that the view of Messrs. St. John and Worthen is correct, namely, that these two forms of teeth belong to different jaws, upper and lower. Which belongs to which we have, however, no really accurate means as yet of determining. Messrs. St. John and Worthen refer the broader teeth (*b* of the present specimen) to the lower jaw on account of "the somewhat stronger resemblance" which they have in form "with the contour of the mandibular teeth of typical cochliodonts."

But whether the form (*a*) or the form (*b*) be upper or lower, I must hold that these larger tooth plates in *Psephodus* present an unmistakeable analogy in form with those of *Cochliodus*. And if this be the case, the long side of each along which the progressive increase of the tooth took place as indicated by the lines of growth, must be *internal* in position, and not *external* as it is placed by Mr. Davis in his figures. This position also brings the oblique directions of the undoubted anterior and posterior margins into harmony with those of the anterior and posterior margins of the great posterior tooth of *Cochliodus*, and of the lines separating the rows of teeth in the recent *Cestracion*, which all cross the jaw obliquely from within outwards and forwards—a direction precisely opposite to what is seen in Mr. Davis's hypothetical figure of the dentition of *Psephodus*. Mr. Davis seems to be quite aware that, in placing the teeth so, he has departed from the analogy of *Cochliodus*, for, while he admits that in that genus and in Cochliodontidæ generally, the inrolled teeth increase from the inner side, he states that in *Psephodus* the increase takes place along the opposite or outer side (*op. cit.* p. 416). It does not seem clear on what reasons this opinion is founded.[1]

The imaginary nature of Mr. Davis's restoration is further illustrated by the fact that in the present specimen the two teeth of the form supposed by Mr. Davis to be "posterior" and "middle" are nearly exactly of the same length. This is indeed what we might expect if they belonged to upper and lower jaws, whereas in the figure referred to, the supposed "middle" tooth is, to suit the tapering form of the jaw, much smaller than the "posterior" one behind it.

On the whole, I consider that view to be most likely to be correct, which would ascribe to the mouth of *Psephodus* four large tooth-plates—two above and two below—each occupying on the ramus a position similar to that of the row of largest teeth in *Cestracion*, or of the so-called median tooth of *Cochliodus*, but that of the upper jaw differing slightly in form from the one opposed to it below. If Messrs. St. John and Worthen's allocation of these larger teeth be correct, the tooth (*a*) of the present specimen will belong to the right half of the middle jaw, while (*b*) will be that of the left half or ramus of the mandible.

The subtrigonal tooth considered by M'Coy and Davis as "anterior" does not occur in our specimen, but it clearly appertains also to *Psephodus*, and there is no reason why it should not also have occupied a position in front of the large ones (*a* or *b*).

Teeth of different forms seem to have been present in the jaw external to, and in front of the large plate; those in its immediate vicinity belonging more or less to the category of *Helodus planus*, including the peculiar forms figured (*e*), and that resembling *Helodus rudis*. But the front of the jaw was armed with small teeth belonging to the type, which has been designated as *Lophodus* by Romanowski, and the forms *didymus* and *lævissimus*, both named as species of *Helodus* by Agassiz. Hence, not only must those species be merged in *Psephodus*, but the genus *Lophodus*, founded upon *H. didymus* and allied forms, ceases to have any but a conventional existence. It would, I think, have been well, before separating off any new genera from the old *Helodus* of Agassiz, to have sought for more precise information as to the essential characters of the Coal-measure species *H. simplex*, which, as it occurs first both in

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[1] In placing the long or obtusely angulated margin of the supposed "posterior" tooth (*b* of our specimen) outwards, Mr. Davis apparently follows M'Coy's description. But in describing the supposed "middle" tooth (*a*) M'Coy calls its long margin "inner," and though Mr. Davis quotes this description verbatim, he, nevertheless, with some inconsistency places the long margin in exactly the reverse position, namely, *external*.

Agassiz's systematic catalogue and in his descriptions, 1
according to the rules usually followed, be considered as the ty
the genus.[1] It is to be hoped that more satisfactory information
the real characters and affinities of that form may soon be f
coming. Meanwhile it would seem that the teeth known as *Lop*
are in fact those situated in the anterior part of the mouth of g
more or less allied to *Cochliodus*. For although Professor Ow
his paper "On the Teeth of Cochliodonts," held that there is
ground for assuming that the symphyses were prolonged,
Cestracion, for the support of conical or any other teeth,"[2] M
Newberry and Worthen have, as is well known, described a s
of *Cochliodus* (*C. nobilis*) from the Carboniferous Limesto
Illinois, in which, with the Cochliodont plates, were associated
of decidedly Lophodont configuration (*Helodus nobilis*, N. & V
such a way as to lead to the belief that these "occupied the c
portion of the jaw in two or more rows between the large conv
teeth which we have described under the name of *Cochliodus no*
And regarding the very species of *Lophodus* occurring on our p
specimen, these authors remark on a previous page:—"The m
teeth of *Cochliodus*, a group which must include several des
species of *Helodus* (e.g. *H. lævissimus*, *H. didymus*, *H. turgidus*,
have been found in regularly diminishing series like some of
now figured."[3] It is now shown that two of those (viz. *lævis*
and *didymus*) occupied a position in the front of the mou
Psephodus, which, although not *Cochliodus*, has certain ob
points of affinity with it. *Psephodus* is still included in the Co
dontidæ by Messrs. St. John and Worthen.[4]

EXPLANATION OF PLATE VIII.[5]

FIG. 1. Anterior part of the specimen of *Psephodus magnus* described in th
showing what remains of the teeth and cartilage of the jaws.
- (*a*) Tooth supposed to be the "middle" tooth of *Psephodus*
by M'Coy and Davis, seen from its attached surface.
- (*b*) Portion of tooth supposed by these authors to be the "pos
tooth.
- (*g*) Teeth referable to *Helodus* or *Lophodus lævissimus*.

,, 2. Portion of the same specimen split off and turned up, showing ad
teeth.
- (*b*) Tooth whose broken margin is shown at *b* in the previous
- (*c*) Tooth of type of *Helodus rudis*, M'Coy.
- (*d*) *Helodus planus*.
- (*e*) *Helodont* teeth of peculiar form.
- (*f*) *Helodus* or *Lophodus didymus*.
- (*g*) *Helodus* or *Lophodus lævissimus*.

,, 3. Tooth *a* in Fig. 1, seen from its convex surface.

,, 4. Tooth *b* in Figs. 1 and 2, seen from its convex surface.

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[1] *Note added* July 20th. A recent examination of the specimens of
simplex in the British Museum has convinced me that these teeth are
"Lophodont" in form, and consequently the genus *Lophodus* must be alt
abolished.

[2] GEOL. MAG. Vol. IV. 1867, pp. 59-63.

[3] Geol. Survey of Illinois, vol. ii. Palæontology, p. 74.

[4] Geol. Survey of Illinois, vol. vii. Palæontology.

[5] [This Plate is by permission of the Council of the Geol. Soc. of Glasgow
to appear in the GEOLOGICAL MAGAZINE.]

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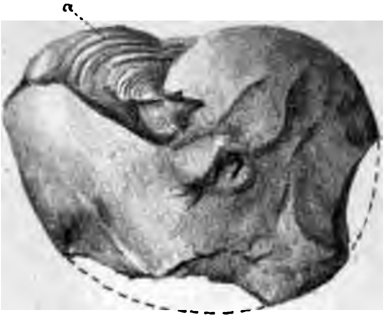

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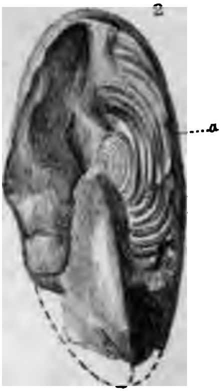

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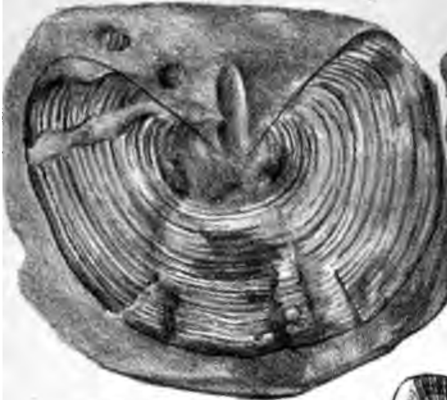

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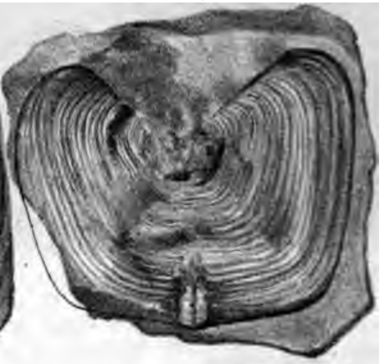

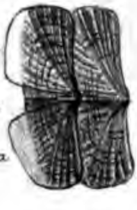

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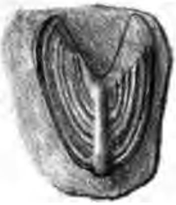

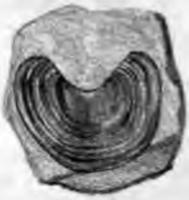

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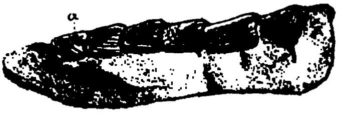

West Newman & Co

E.C. Woodward lith.

Devonian, Bicken, Nassau

Chiton.

II.—ON SOME PALÆOZOIC PHYLLOPOD-SHIELDS, AND ON *NEBALIA* AND ITS ALLIES.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S., etc.

(PLATE IX. FIGS. 1-6.)

IN a paper lately published in the "Neues Jahrbuch" (Band i. 1884), Herr W. Dames, of Berlin, has made some observations "On the Phyllopod-nature of *Spathiocaris*, *Aptychopsis*, and similar bodies," met with in strata of Silurian, Devonian and Carboniferous ages in Europe and North America, and described by Barrande, Salter, M'Coy, Meek, Hall, Clarke, Jones, myself, and others.

After an elaborate criticism of the subject, the author concludes:—

1.—That some of the bodies in question are the *Aptychi* of *Goniatites*.

2.—That for others, this explanation is, according to our present knowledge, inadmissible.

3.—That the last are, however, in no case Phyllopods.

(1.) In reference to the first conclusion, Herr Dames refers to the discovery by Herr Kayser of a specimen of *Goniatites intumescens*, from the Devonian of Bicken, with an *Aptychus* lying in its body-chamber (Zeitschrift der Deutsch. Geol. Gesellsch., 1882, bd. xxxiv. p. 819). Not having seen the specimen briefly referred to by Herr Kayser (of which no figure is given), I was unable to offer an opinion as to the correctness, or otherwise, of Herr Dames' conclusion.

The British Museum has, however, lately obtained from Krantz and Co., of Bonn, several specimens of these *Aptychus*-like[1] bodies, from the black limestone of Bicken; and my colleague, Mr. Robert Etheridge, jun., has fortunately discovered among them a specimen of a small *Goniatites intumescens* with an imperfect *Aptychus in sitû* in its mouth-aperture.

I give a figure of the specimen in the accompanying Plate (Pl. IX. Figs. 1, 2).

This *Aptychus* seems to agree most nearly in form with my so-called "*Cardiocaris lata*," from Budesheim in the Eifel,[2] also observed by Mr. Clarke at Bicken.[3] The other specimens of *Aptychus*-like bodies, not *in sitû*, but from the same black Devonian limestone, agree *very closely* with Mr. J. M. Clarke's *Spathiocaris Koeneni* (see Neues Jahrbuch, 1884, bd. i. hft. 2, p. 182, taf. iv. fig. 1), from Bicken.

The discovery made by Herr Kayser, at Bicken, of a Goniatite-shell with an *Aptychus* lying in its body-chamber, and casually noticed in 1882,[4] having now been verified by the finding of another specimen, in which the *Aptychus* is seen fitting the aperture of the mouth of the shell (as first observed in *Ammonites subradiatus* from the Inferior Oolite of Dundry, and described by the late Dr. S. P. Woodward, F.G.S.; see "Geologist," 1860, vol. iii. p. 328, and woodcut figure), it will be necessary to re-examine with great care all those forms of supposed Phyllopod-shields which occur in beds in which *Gonatities* have been found. But, even after this task has been carefully performed, we feel convinced, with Herr Dames:—

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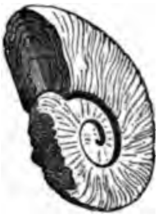
[1] Labelled "*Stromatopora concentrica*, Goldf., Culm, Bicken bei Herborn, Nassau." I have also received a specimen of *Aptychus* from my friend Mr. John Edward Lee, F.G.S., of Torquay, sent to him by Prof. Ferd. Roemer, of Breslau, and labelled "*Aptychopsis*, sp. = operculum of *Goniatites intumescens*, Upper Devonian, Bicken, near Herborn, Nassau," in Dr. Roemer's own handwriting.

[2] See GEOL. MAG. 1882, Dec. II. Vol. IX. Pl. IX. Fig. 13, p. 388.

[3] See "Ueber deutsche oberdevonische Crustaceen von. J. M. Clarke, zur zeit in Göttingen," Tafel. iv. fig. 2, N. Jahrbuch f. Min. etc. 1884, bd. i. p. 181.

[4] Zeitschr. der Deutsch. Geol. Gesellsch. bd. xxxiv. p. 819.



Ammonite, with *Aptychus* in situ. From the Inf. Oolite, Dundry.

(2.) "That for others, this explanation is, according to our present knowledge, inadmissible."

And here it is only necessary to refer the reader to the Reports drawn up by Professor T. Rupert Jones, F.R.S., and myself,[1] on the Phyllopoda, in order to confirm Herr Dames' own conclusion that all the simple disc-like or bivalved-shields, met with in the older rocks, cannot be referred to the opercula of the Cephalopoda.

Then as to the substance of these *Aptychus*-like forms, it is not without interest to notice, that whereas the greater number of the Mesozoic *Ammonitidæ* had thick shelly opercula, only a very few had thin horny ones. I do not understand Herr Dames clearly if he says that the *Aptychi* of Secondary Ammonites consist of *only one piece*. I have examined a very great number, and they all have a mesial suture and most of them readily divide into the two halves, corresponding with the two conjoined dorsal arms, which form the hood in the recent *Nautilus*, and which secreted the shelly operculum in the Ammonites.

There are many special characters about these Palæozoic Phyllopod-shields that, even when they are not found associated with body-segments, will require to be carefully examined before they can all be referred to *Goniatites*.

We would draw attention to the varied form of the notch; the absence in some, and the presence in others, of the dorsal suture; the presence in different genera of the rostral portion of the shield in the circular and oval forms, and the possible existence in some of a hinder trigonal shield-piece (*Pholadocaris, Dipterocaris*); the shape of the shield itself; the ornamentation; and, lastly, the substance composing it. Usually it is possible to discern the difference in character between Crustacean and Molluscan structures, as also between these and obscure ichthyic fragments.

It is desirable to add, that many of the genera to which Herr Dames takes exception were not hastily established, nor without study on the part of their founders. Barrande and Salter always proceeded with extreme caution, and, if we have been sometimes misled in the diagnosis of a fossil, we have most readily and gladly corrected such error when our attention has been drawn to it.

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[1] Geol. Mag. 1883, Decade II. Vol. X. pp. 461-464. *Op. cit.* 1884, Decade III. Vol. I. pp. 348-356, and more fully in Brit. Assoc. Reports, Southport, 1883, and Montreal, 1884, Section C. Geology.

(3.) In the third conclusion, "that even those forms which cannot be referred to *Aptychi* of Cephalopods, are in no case the shields of Phyllopods," Herr Dames is simply stating a matter of opinion; for of their exact nature and true zoological position Claus himself (to whom he seems to refer) is not at all positive, whilst Dames admits that he has not examined the original specimens.

As an illustration of unsupported dogmatic assertion, take the following paragraph in reference to the body-rings of *Discinocaris;* "Even if the structures observed are really body-rings, no stronger proof against their phyllopod nature could be brought forward; for the body-rings, as well as all the other parts, of the Phyllopod (except the shell), are *too tender and fragile* to remain recognizable in beds of such great age"[1] (Dames, *op. cit.*).

In the presence of the long array of Insect-remains, of the most delicate and fragile character, discovered in the Devonian and Carboniferous formations, from North America, France, England, Belgium, Bohemia, and elsewhere, this argument against the possibility of delicate organisms being preserved falls to the ground; whilst the relative thickness and durability of the calcareous or chitinous covering of the body-segments in these ancient Crustacea afford no proof for or against their Phyllopod nature, any more than does their relatively greater size when contrasted with existing Entomostraca. Moreover, body-rings of *Ceratiocaris* are by no means rare in some Silurian strata.

I have long held the opinion that the expanded disc-like shields such as *Peltocaris, Discinocaris, Aptychopsis*, and some others, were probably related ancestrally to the larval or adult forms of Phyllopods like *Apus, Lepidurus*, etc., whilst the relationship between the living *Nebalia* and the numerous genera of Palæozoic pod-shrimps, does not necessarily preclude us from considering these forms as still belonging to the ENTOMOSTRACA, although they may be placed in Packard's order PHYLLOCARIDA (see *infra*).

As to the question of ornamentation, upon which Herr Dames insists so strongly, the concentric striæ, marking lines of growth, appear to me to correspond most closely in character and origin with the similar decoration observable on the valves of *Estheria, Limnadia*, etc., so that their absence upon the carapaces of *Apus* and *Nebalia* does not necessarily prove that shields so ornamented cannot be deemed to belong to Crustacea or even to the PHYLLOPODA; whilst many of the carapaces of the fossil genera, e.g. *Dithyrocaris, Ceratiocaris*, etc., have either concentric or anastomosing striæ covering the entire surface of their carapaces; yet Herr Dames has evidently no doubt that these forms are related to *Nebalia*, which has a smooth carapace destitute of ornamentation.

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[1] Prof. A. von Koenen, replying to Herr Dames, on behalf of Mr. J. M. Clarke, very justly observes, " I cannot see that this at all meets the argument, since the relative age of strata is of altogether little influence on the preservation of fossils; on the other hand, there are plenty of examples in which fossil animals have been furnished with hard, horny and even calcareous parts which are wanting in their nearest recent analogues. I will only recall here *Aptychus* and *Anaptychus*, von Koenen." (N. Jahrbuch ii. Bd. i. Heft. 1884, p. 45.)[1]

[1] The recent *Nautilus* has a fleshy hood; the fossil Ammonite had usually a hard calcareous *operculum*, but in some Liassic forms the operculum was *horny*.

He reminds us that Claus and Gerstaeker are of opinion that *Nebalia* is not a *Phyllopod*. Because *Nebalia* during its embryonal life (whilst still in the egg) passes through the "Nauplius-" and "Zoëa-stages," which in Decapods occur partly in the free state, it has been regarded, by some, as a "Phyllopodiform-Decapod;" but as it never attains a higher development as an adult than that of a Phyllopod, and has no retrograde metamorphosis, may we not with as equal reason regard *Nebalia* as a highly-organized *Phyllopod*, as to assert that it is a Decapod arrested at the Phyllopod stage?[1]

All who have studied the PHYLLOPODA have been struck by the peculiar points of special interest to be observed in *Nebalia*.[2]

Milne-Edwards, in his "Histoire Naturelle des Crustacés" (1840), places *Nebalia* in the family *Apusidæ* among the Phyllopods; at the same time he remarks, "The *Nebaliæ* are very singular little crustaceans, which by reason of their stalked eyes,[3] and their carapace, approach the PODOPHTHALMIA; they do not however possess branchiæ, properly so-called, but they respire by the aid of their thoracic feet, which are developed into membranaceous and foliaceous appendages. They resemble in many respects and establish a passage between *Mysis* and *Apus*."

Baird (1850) founded the family *Nebaliadæ*, and regarded *Nebalia* as a Phyllopod.

Prof. J. D. Dana (1853), in his great work on the Crustacea retained the family name (*Nebaliadæ*), which he placed in the PHYLLOPODA.

Metschnikoff, in 1865, published an abstract of his account of the development of *Nebalia Geoffroyi*, and in 1868, the full essay in Russian. Fritz Müller, in his "Für Darwin," states that Metschnikoff has observed, "that *Nebalia*, during its embryonal life, passes through the Nauplius and Zoëa-stages, which in the Decapoda occur partly (in *Penæus*) in the free state." "Therefore," he adds, "I regard *Nebalia* as a Phyllopodiform Decapod."

In 1872, Claus gave an account, with excellent figures, of the external anatomy of *Nebalia Geoffroyi*, and, in 1876, he described the internal anatomy.

In 1875, in the account of the Atlantic Crustacea of the "Challenger Expedition," Willemoes-Suhm placed the *Nebaliadæ* among the *Schizopoda*.

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[1] The *potentiality* of a form to attain to a higher existence seems to be mistaken here for *actuality*. It is the story of the French soldier with the marshal's baton in his knapsack and the American boy who feels within him the potentiality of becoming *some day* President!

[2] For a very full and admirable account of *Nebalia* see the 12th Annual Report of the United States Geological Surveys, Part I. Geology, Palæontology and Zoology, 8vo. 1883 (Washington), "A Monograph of the Phyllopod Crustacea of North America, with remarks on the order *Phyllocarida*," by A. S. Packard, jun., pp. 295–592, and plates i.–xxxix. See also the "American Naturalist" for Oct. Nov and Dec. 1882, vol. xvi. pp. 785, 861, 945.

[3] Pedunculated eyes are also present in *Branchipus* and *Artemia*, so that the stalked eyes of *Nebalia* can hardly be regarded as an essential character.

In 1879, Dr. A. S. Packard, jun., in the "American Naturalist," vol. xiii. p. 128, proposed that *Nebalia* and its fossil allies should be placed in a new order, which he proposed to name the PHYLLOCARIDA. Dr. Packard writes :—

"The *Nebaliadæ*, represented by the existing genus *Nebalia*, have generally been considered to form a family of Phyllopod Crustacea. Metschnikoff, who studied the embryology of *Nebalia*, considered it to be a 'Phyllopodiform Decapod.' Besides the resemblance to the Decapods, there is also a combination of Copepod and Phyllopod characteristics. The type is an instance of a generalized one, and is of high antiquity, having been ushered in during the earliest Silurian Period, when there were (when we regard the relative size of most Crustacea, and especially of living *Nebaliæ*) gigantic forms. Such was *Dithyrocaris*, which must have been over a foot long, the carapace being seven inches long.[1] The modern *Nebalia* is small, about half an inch in length, with the body compressed, the carapace bivalved as in *Limnadia*, one of the genuine Phyllopods. There is a large rostrum overhanging the head; stalked eyes; and, besides two pairs of antennæ and mouth-parts, eight pairs of leaf-like, short, respiratory feet, which are succeeded by swimming feet. There is no metamorphosis, development being direct.

Of the fossil forms, *Hymenocaris* was regarded by Salter as 'the more generalized type.' The genera *Peltocaris* and *Discinocaris* characterize the Lower Silurian Period, *Ceratiocaris* the Upper, *Dictyocaris* the Upper Silurian and the lowest Devonian strata, *Dithyrocaris* and *Argas* the Carboniferous Period. Our existing north-eastern species is *Nebalia bipes* (Fabricius), which occurs from Maine to Greenland.

The Nebaliads were the forerunners of the DECAPODA, and form, we believe, the type of a distinct order of Crustacea, for which the name PHYLLOCARIDA is proposed."

The order PHYLLOCARIDA is thus defined :—

PHYLLOCARIDA, Packard (1879). Body long, with 5 cephalic, 8 thoracic, and 8 abdominal segments, with a thin or chitinous skin; generally covered with a bivalved shell having a moveable rostrum. Eyes pedunculated and faceted. Upon the under side of the head are two pairs of antennæ; the mandibles, and two pairs of maxillæ furnished with palpi. The body-segments are compressed, they support eight pairs of large Phyllopodiform thoracic feet. The abdomen composed of eight large segments,[2] provided with six pairs of simple swimming-feet fringed with setæ, of which the four anterior pairs are the largest, and the two posterior pairs are very small. The abdomen terminates in setaceous filaments, or in a telson divided into three or more parts. (Zittel, "Handbuch der Palæontologie," Munich, i. Band, ii. Abth., iv. Lief. p. 656, July, 1885.)

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[1] The Devonian *Dithyrocaris Neptuni* of Hall must have been some two feet or perhaps more in length.

[2] The abdomen is nine-jointed, unless the last somite be considered as the telson (it is post-anal). It is a long and slender segment, and bears two very long narrow setigerous cercopods, closely resembling those of the COPEPODA.

In 1880, Prof. Claus, "Lehrbuch der Zoologie," writes, "This remarkable form (*Nebalia*) was for a long time regarded as a Phyllopod, and in many of its characters it represents a connecting-link between the PHYLLOPODA and the MALACOSTRACA. The structure and segmentation of the head and thorax resembles that of the Malacostraca, but the terminal region of the abdomen does not present the special form of a caudal plate or telson.

In *Nebalia* we probably have to do with an offshoot of the Phyllopod-like ancestors of the MALACOSTRACA, which has persisted to the present time."[1] He adds, "*Nebalia* is best placed in a special group LEPTOSTRACA, between the ENTOMOSTRACA and MALACOSTRACA. The Palæozoic genera *Hymenocaris, Peltocaris*, etc., would have to be placed in such a group."[2]

In his "Handbuch der Palæontologie," Munich, 1885, Prof. Dr. K. A. Zittel adopts Packard's order PHYLLOCARIDA, but places it under the MALACOSTRACA, and between the EDRIOPHTHALMIA and the MEROSTOMATA.

In his article on the Palæozoic allies of *Nebalia*, Mr. A. S. Packard, jun., thus sums up the PHYLLOCARIDA: "From our total lack of any knowledge of the nature of the limbs of the fossil PHYLLOCARIDA, we have to be guided solely by analogy, often an uncertain and delusive guide. But in the absence of any evidence to the contrary, there is every reason to suppose that the appendages of the head, thorax, and abdomen were on the type of *Nebalia*, since there is such a close correspondence in the form of the carapace, rostrum, and abdomen.

"But whatever may be the differences between the fossil forms represented by *Ceratiocaris*, etc., they certainly seem to approach *Nebalia* much nearer than any other known type of Crustacea; they do not belong to the DECAPODA; they present a vague and general resemblance to the zoëa or larva of the Decapods, but no zoëa has a telson, though one is developed in a postzoëal stage; they do not belong to any other Malacostracous type, nor do they belong to any existing Entomostracous type, using those terms in the old sense. No naturalist or palæontologist has referred them with certainty to the Decapods, or to any other Crustacean type than the Phyllopods. To this type (in the opinion of Metschnikoff and Claus, who have studied them most closely) they certainly do not belong, and thus reasoning by exclusion they either belong to the group of which *Nebalia* is a type, or they are members of a lost, extinct group. The natural conclusion, in the light of our present knowledge, is, that they are members of the group represented by the existing *Nebalia*." "The differential characters separating them from the Decapods or any other Malacostracous type are:—

1. The loosely-attached carapace, the two halves connected by an adductor muscle.

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[1] Claus, translated by Sedgwick (Cambridge), p. 448, 8vo., 1884.

[2] *Ibid*, in a footnote to p. 448. LEPTOSTRACA.—The *Leptostraca* (Claus) are thus defined: "Crustacea with thin skins, mostly bivalved, and with carapaces under which the body-rings remain separate as free body-segments" (Zittel's Handbuch der Palæontologie, July, 1885, i. Band, ii. Abth., iv. Lief. p. 655.)

2. The moveable rostrum, loosely attached to the carapace.

3. The very long and large mandibular palpus; the long slender appendage of the first maxilla, and the very long bi-ramous maxillæ.

4. The absence of any maxillipeds.

5. The eight pairs of pseudo-phyllopod thoracic feet, not adapted for walking.

[To these we would add:—5*a*. The 'telson' long and slender, with two long narrow setigerous cercopods as in the Copepoda.]

6. The animal swimming on its back.

7. No zoëa-formed larva.

The characters which separate it from the Phyllopods are:—

1. Carapace not hinged; a rostrum present.

2. Two pairs of well-developed long and large multiarticulate antennæ; the hinder pair, in the male, longer than the first pair.

3. The thorax and its appendages clearly differentiated from the abdomen."[1]

Nebalia has been so long regarded as the surviving representative of those more ancient and gigantic forms of PHYLLOCARIDA, which existed in such numbers in the Cambrian and Silurian Seas, and became nearly extinct towards the close of the Carboniferous epoch, that any decision affecting its zoological position cannot be a matter of indifference to the palæontologist.

But after studying its larval development, and adult structural modifications, we arrive at the fact that *Nebalia* is a more generalized type than is ordinarily to be found at the present day, "combining Copepod, Phyllopod, and Decapod-like features, with other more fundamental characters of its own,"[2] which preclude us from regarding it as a true Malacostracan, and, although ancestrally related to that order, it nevertheless does not attain in my opinion to the Malacostracan grade of development.[3] They should therefore be arranged in a distinct order (the PHYLLOCARIDA), between the ENTOMOSTRACA and the MALACOSTRACA, as suggested by Claus. But if it is undesirable to have such an outstanding group, then I contend that the balance turns in favour of retaining it in the former division, if not indeed in the order PHYLLOPODA as heretofore.

"It is," writes Prof. Claus, "in the highest degree probable, however, that all these" (Palæozoic PHYLLOCARIDÆ) "are not true Phyllopods, but have belonged to a type of Crustacea, of which now there are no living representatives, but which, taking their origin from forms allied to the lower types of Entomostraca, have prepared the way for the Malacostracan type. Such a connecting link, which has served to the present day, we evidently find in the genus *Nebalia*."[4]

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[1] American Naturalist, 1882, vol. xvi. p. 951; and Monograph N. Amer. Phyllopods, etc. 1883, pp. 447-8.

[2] Packard.

[3] Dr. Packard writes, "There is little to indicate that the Schizopods (*Mysis*, etc.) have descended from a *Nebalia*-like form, but rather from some accelerated zoëa form; while the PHYLLOCARIDA *have had no Decapod-blood in them*, so to say, but have descended by a separate line from Copepod-like ancestors, and culminated, and even began to disappear, before any Malacostraca, at least in any numbers, appeared" (American Naturalist, 1882, vol. xvi. p. 873).

[4] Claus in Siebold and Kolliker's Zeitschrift, xxii. 1872, p. 329.

From noticing a Goniatite-*Aptychus in situ*, I have quite unintentionally been led into a lengthened discussion upon Phyllopod shields and the relations of the living *Nebalia* to the ancient PHYLLOCARIDA.

Some of the results of this paper I may briefly summarize thus:—

1. I have acknowledged that some of the supposed "Phyllopod-shields" from Budesheim described by me (GEOL. MAG. 1882, Decade II. Vol. IX. pp. 385–390, Pl. IX.) are probably *Aptychi* of *Goniatites*.

2. That for others of the described Palæozoic Phyllopods, alluded to in Prof. T. R. Jones's Reports of 1883–84, this explanation is inadmissible.

3. That those which cannot be referred to *Aptychi* are still, in all probability, Phyllopods.

4. That even the *Nebalia*-like forms, now placed in the order PHYLLOCARIDA, are *certainly not Decapods*. And even if they may not with propriety be retained any longer in the old order PHYLLOPODA (of which I am by no means sure), yet they may with more correctness be placed beside them in the ENTOMOSTRACA, rather than in the MALACOSTRACA, seeing they have not actually attained to the grade of the latter, but only approached to its larval development; whilst to the former the adult *Nebalia* has many very strong points of affinity.

I cannot conclude these remarks without observing that, whilst deprecating the tone of parts of Herr Dames's criticism of my work as at times too dogmatic for one who has not himself specially studied this group of organisms, and as not calculated to promote friendly feeling between fellow-workers, yet I would express the hope, that, even though we differ in opinion, we may still maintain the same good relations as heretofore.

EXPLANATION OF PLATE IX. FIGS. 1-6.

FIG. 1. Side-view of *Goniatites intumescens*, Upper Devonian? with *Aptychus* (*a*) in situ occupying the aperture.
,, 2. View of the mouth of same specimen showing the *Aptychus* (*a*) fitting the aperture.
,, 3. A detached *Aptychus*, obtained at Bicken, by Prof. Dr. Ferdinand Roemer, and presented by him to Mr. John Edward Lee, F.G.S., of Torquay.
,, 4. Another detached *Aptychus* from the same locality.
,, 5. Ditto.
,, 6. Ditto.

All from the Upper Devonian of Bicken near Herborn in Nassau, Germany; and all drawn of the natural size.

III.—ON A NEW SPECIES OF *HELMINTHOCHITON* FROM THE UPPER BALA (SILURIAN) OF GIRVAN, AYRSHIRE.

By HENRY WOODWARD, LL.D., F.R.S., etc.

(PLATE IX. FIGS. 7-12.)

MY friend Prof. T. Rupert Jones, F.R.S., has lately received several Palæozoic fossils for examination from the rich collection of Mrs. Robert Gray, of Edinburgh, and has, with the owner's kind permission, placed two pieces of a very remarkabte fossil in my hands, for the purpose of examination and description.

The specimens under consideration were obtained by Mrs. Gray from the Upper Bala Beds of Thraive, near Girvan (of Lower Silurian age).

These pieces, viewed apart, displayed the impression of six somewhat oblong imbricated plates, ornamented with lines of growth, coinciding with the lower and anterior borders of each plate; and also traversed obliquely by a number of transverse radiating furrows or ribs, one of which is more prominent than the rest, running from the posterior dorsal angle of each plate to the anterior lower border, and radiating upwards. When the two pieces are united, a narrow wedge-shaped space remains, once filled with the organism itself, of which the matrix has preserved a faithful copy of the exterior of the two sides. By running in some very fine plaster of paris, I have been enabled to obtain a cast from this natural mould, which fairly represents in plaster the actual form of the testaceous covering of the lost organism. We at once perceive that each quadrate plate was strongly carinated and was bilaterally symmetrical; that each plate was imbricated, *i.e.* it overlapped the succeeding plate, like a row of ridge-tiles upon a house-roof (see Pl. IX. Figs. 7, 8, 9).

The length of the six plates is 35 millimètres, that of the most anterior plate 5 mm.; of the second 5 mm.; of the third 6 mm.; of the 4th 6 mm.; of the fifth 6 mm.; and of the sixth 7 mm.; the average depth appears to be 5 mm. Allowance must however be made owing to the breaking off of the thin margins of the plates in the mould, where one plate has overlapped another. I am inclined to believe that the first plate in the series, which is more rounded off than the rest, was probably the true anterior or cephalic extremity (see Pl. IX. Fig. 7*a*), and that if a part of the organism is lost, which seems equally certain, it was from the other extremity, which is fractured across close to the edge of the sixth plate.

The first and second plates were apparently rather smaller than the rest; but the concentric and radiating lines which divide each plate or valve into three parts, a dorsal and two lateral areas, are observable on all.

What then was the nature of this fossil? and to what class of organisms should it be referred?

So long ago as 1857, Prof. L. G. de Koninck published[1] some observations on two new species of *Chiton* from the Upper Silurian (Wenlock Limestone) of Dudley, namely, *Chiton Grayanus*, and *Ch. Wrightianus*.

The first of these two species, *Chiton Grayanus*, has remained unchallenged; but the determination of the second, *Chiton Wrightianus*, was called in question by me in 1865, and in a paper read before the Geological Society in that year, I showed that *Ch. Wrightianus* was identical with a recently discovered fossil named by me *Turrilepas*—

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[1] Bulletin de l'Académie Royale des Sciences, etc., de Belgique, 26 Année, 2nd ser. tome iii. Bruxelles, 1857, pp. 190–199, pl. i.; see also Ann. and Mag. Nat. Hist. 1860, 3rd ser. vol. vi. pp. 91–98, pl. ii. translation by W. H. Baily, F.G.S.

having as many as four rows of plates in its test; that it agreed with this newly-discovered fossil in having the two sides of each principal row of plates unsymmetrical; that it could not be referred to *Chiton*, because it had more than eight plates in the series; and that the surfaces of the plates were uniformly sculptured, and not divided into areas, as in *Chiton* proper.[1]

Specimens of *Turrilepas* have been obtained from the Silurian rocks of Bohemia, and described by the late M. J. Barrande under the name of *Plumulites* (Syst. Silur. de la Bohême, vol. i. Suppl. 1872, p. 565).

A species has also been described and figured by R. Etheridge, jun. (Proc. Roy. Ph. Soc. Edin. 1878, vol. iv. p. 166, tab. 2. figs. 1 and 2), from Balcletchie, near Girvan, in a fine-grained greenish Silurian Mudstone. (See Mon. Silur. Fossils, Girvan District, Ayrshire, by H. A. Nicholson and R. Etheridge, jun., vol. i. 1880, pp. 214–215, pl. xiv. figs. 22–27.)

I have compared Mrs. Gray's specimen from Thraive with *Turrilepas* from the Wenlock Shale, and I find that it differs in the following particulars.

Mrs. Gray's specimen has the two sides of each valve bilaterally symmetrical. In *Turrilepas* the two sides of each valve are unequal. The ornamentation upon the valves of the Thraive fossil is not uniform, being partly composed of concentric lines of growth, and partly of radiating ribs or striæ, which divide each valve into three areas (a median and two lateral ones).

The ornamentation in *Turrilepas* consists of uniform fine wavy striæ, which cover the whole surface of each valve. Finally, *Turrilepas* is known to consist of several rows of imbricated plates, which vary in form, but not in ornamentation; whereas Mrs. Gray's fossil has its shell composed of a single row of imbricated plates closely resembling each other in form.

The form of the plates in the Girvan fossil is peculiar, but it most nearly resembles that of Salter's genus *Helminthochiton*, and it is to this genus I venture to refer it.

Family CHITONIDÆ. Genus CHITON, L. Shell composed of eight transverse imbricating plates, lodged in a coriaceous mantle, which forms an expanded margin round the body. The first seven plates have posterior apices; the eighth has its apex nearly in front. The six middle plates are divided by lines of sculpturing into a dorsal and two lateral areas. All are inserted into the mantle of the animal by processes (apophyses) from their front margin. The posterior plate was considered homologous with the limpet-shell by Dr. J. E. Gray; the other plates appear like portions of its slope, successively detached. The border of the mantle is either bare, or covered with minute hairs or spines (S. P. Woodward).

Sub-genus HELMINTHOCHITON, Salter, 1847. Quart. Journ. Geol. Soc. 1847, vol. iii. pp. 48–52.

Form elongate, plates subquadrate, thin; apex of the anal plate remote from its front edge; apophyses widely separated; shell not covered by the mantle.

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[1] See Quart. Journ. Geol. Soc. 1865, vol. xxi. pl. xiv. figs. 1*a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, *l*, pp. 486-489.

Helminthochiton Griffithi of Salter is recorded in Griffith and M'Coy's Synopsis of the Silurian Fossils of Ireland, Dublin, 1846, and five figures are given (plate v. fig. 5*a*-*e*), and in the Addenda, p. 71, M'Coy gives a short account of the fossil, which he describes as "Linear-oblong, *smooth*, carinate; plates bent at a low angle, thin, deeply emarginate behind; no distinct lateral area; cephalic plate half-oval, longer than wide, marked with four or five faint radiations, and a few lines of growth."

M'Coy gives the locality as Coolin, Galway (in flaggy mudstone) [Salter gives the locality as Cong, co. Galway]. Salter gives a woodcut (on p. 49, op. cit.); it has the same subquadrate form as our fossil, but does not display the same ornamentation as that from Girvan. This may, however, be due to the nature of the matrix, and the state of preservation of the fossil.

In any case it would not be safe to refer the Girvan Chiton to Salter's species from Galway, seeing they differ from one another considerably in the form of the valves, which, in the Irish specimen, are shorter and deeper than in that from Girvan.

H. Griffithi is also destitute of ornamentation, or nearly so, whilst the Girvan form is ornamented with both concentric and radiating lines.

In his paper on fossil Chitons, Prof. de Koninck gives a list of all the species of Palæozoic Chitons known to him in 1857, which we here subjoin:—

PERMIAN.

Chiton Loftusianus, King. (and Carboniferous ?)
,, *Howseanus*, Kirkby.
,, (?)*cordatus*, ,, (and Carboniferous).
Chitonellus Hancockianus, Kirkby.
,, *distortus*, ,,
,, *antiquus*, Howse.

CARBONIFEROUS LIMESTONE.

Chiton concentricus, De Kon.
,, *gemmatus*, ,,
,, ,, var. *mosensis*, De Ryckh.
,, ,, *Viseticola*, ,,
,, ,, *legiacus*, ,,
,, ,, *eburonicus*, ,,
,, *priscus*, Münster.
,, *nervicanus*, De Ryckh.
,, *turnacianus*, ,,
,, *Mempiscus*, ,,
,, (*Chitonellus*) *cordifer*, De Kon.
,, *thomondiensis*, Baily.
,, *Burrowianus*, Kirkby.

[The following additional species of Chitons from British Carboniferous rocks are recorded by Mr. R. Etheridge, jun., F.R.P.S.E., Proceed. Nat. Hist. Soc. Glasgow, 1881, pp. 84–104, pl. i. and ii.

Chiton Dalriensis, R. Etheridge, jun.
,, *Armstrongianus*, R. Eth. jun.

Chiton sp. ind.
,, *soleaformis*, R. Eth, jun.
,, *Geikiei* ,, ,,
,, sp. ind.
Chitonellus subquadratus, Kirkby and Young.
,, sp. ind.
,, (?) *patelliformis*, R. Eth. jun.
,, *Bennieanus*, ,,
,, (?) *Kirkbyanus*, ,,
,, *Youngianus*, Kirkby.]

(*De Koninck's List continued.*)

UPPER DEVONIAN.

Chiton lævigatus, Fr. Ad. Roemer.
,, *tumidus*, De Kon.
,, *fasciatus*, Sandb.
,, *subgranosus*, Sandb.

MIDDLE DEVONIAN.

Chiton corrugatus, G. and F. Sandberger.
,, *cordiformis*, G. Sandberger.
,, *priscus*, ,, non Münster.
,, *Sandbergianus*, De Ryckh.
,, *sagittalis*, G. and F. Sandberger.
,, n. sp.

UPPER SILURIAN.

Chiton Grayanus, De Kon.

LOWER SILURIAN.

Chiton (*Helminthochiton*) *Griffithii*, Salter.

The only species of *Chitonidæ* noticed by G. Lindström, in his Silurian Gasteropoda and Pteropoda of Gotland, Stockholm, 1884, are :—

Chelodes Bergmani, Davidson and King.
,, *Gotlandicus*, Lind.
Chiton, sp. indet.

Besides the specimen above described, Prof. T. Rupert Jones had also received from Mrs. Gray several examples of a small fossil from a black Silurian slate-rock, Balcletchie, near Girvan, named *Solenocaris solenoides* by MM. Young in 1868.[1] The small detached oblong valves originally described by the authors were obtained from the Silurian strata of Penwhapple Glen, near Girvan (see Proc. Nat. Hist. Soc. of Glasgow, 1868, vol. i. part i. pp. 171–173, pl. i. figs. 7*a*, *b*., and Proc. Roy. Phys. Soc. Edinb. vol. iv. 1878, p. 167).

The genus *Solenocaris* of Young is also referred to, under the order *Phyllopoda*, in "Nicholson and Etheridge's Monograph of the Silurian Fossils of the Girvan District in Ayrshire" (fasc. i. 1878, p. 207). The authors point out that the *Solenocaris* of Young (1868) must not be confounded with the *Solenocaris* of Meek (1872).

Messrs. Young thus describe *Solenocaris* :—

"It presents, at first sight, all the characters of a bivalve shell of the Solenoid group; but Mr. Young detected at the posterior part of the hinge-line the peculiar ornament which is comparable only to that found in Crustaceans, and is never found in Lamellibranchs.

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[1] See also Report on Fossil PHYLLOPODA, Brit. Assoc. 1883.

The test is oblong quadrilateral, one quarter of an inch in length, and one fourteenth in breadth. The anterior extremity is truncated vertically, the posterior is gently rounded. The outer surface, on which an eye-spot is visible,[1] is divided into two nearly equal parts, one of which, starting from the anterior superior angle, cuts the lower margin in front of the lower posterior angle. The area anterior and inferior to this furrow is traversed by nine or ten longitudinal ridges, of which the lowest is more elevated than the others, and forms a thickened rim to the test. The posterior and upper triangular area is divided by a triangular ridge, which, narrow at its anterior superior end, gradually widens backwards, and covers more than the lower half of the posterior extremity of the test. Above this ridge is a gently convex surface, bounded superiorly by the slightly thickened dorsal margin. This area is traversed by faint concentric striæ, the continuation of some of the coarser anterior ridges. It is on this area that the ornament above mentioned is seen. It consists of very close-set, minute tubercles, arranged in linear series opposite each other.

The contours of the surface are in several planes. The anterior vertical margin is everted; the remainder of the antero-inferior area is in one plane. The middle of the postero-superior area projects considerably, in consequence of the prominence of the elevated ridge, the upper surface being flattened slightly towards the hinge-line; but posteriorly the surface is flattened very markedly towards the posterior rounded margin, so that the two valves would be approximated pretty closely.

Its resemblance to a gaping bivalve is thus considerable, but on closer comparison the difference will appear well-marked. No Lamellibranch has the anterior greater than the posterior gape; when the relation is not one of equality, the posterior is the larger. *Orthonotus*, the nearest in form, is not one of the gapers, nor is its hinge-line linear, with parallel bounding areas; its oblique, lateral ridges, moreover, cut the inferior margin, not the posterior outline, as in the specimen before us.

The ornament, again, is not that of Lamellibranchs; its granular surface has a corresponding obverse surface seen when the shell has been removed, and exactly similar to that in the internal casts of *Dithyrocaris*. The lateral position of the beak removes the Brachiopoda at once from consideration, though, in some respects, the outer and inner surfaces present appearances not unlike those of *Productus*.

No other conclusion is open except that this form is a Crustacean, and, so far as I am aware, of an undescribed type. Those which are known from the Silurian rocks are *Hymenocaris*, *Peltocaris*, *Discinocaris* and *Ceratiocaris*. In all these the extended carapace forms a shield, with rounded outlines. Our specimen would give a quadrilateral shield.[2] The character of the ornament is wholly peculiar; no less so is the want of the definite emargination seen in the Crustacea above-mentioned.

The absence of distortion in any of the other fossils from the same locality, and the presence of the eversion of the anterior margin in all the specimens, forbids the supposition that this character is accidental.

After a careful study of Messrs. Young's *Solenocaris*, and comparison with the Chiton-like series of plates above noticed, we are led to conclude that there is a very general agreement between them, so far as bodies of the kind can be compared, preserved in such different kinds of matrix.

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[1] I have not been able to satisfy myself as to the presence of the eye-spot here referred to, in any of Mrs. Gray's specimens.—H.W.

[2] We are reminded by the *Solenocaris* of Young of the small oblong bivalved Crustacean carapaces, named by Prof. T. Rupert Jones *Leaia* (see Appendix to a Monograph of the Fossil *Estheriæ*, by T. Rupert Jones, Pal. Soc. Mon. 1862, p. 116, pl. v. figs. 11, 12, *Leaia Leidyi*, Pennsylvania; *L. Leidyi*, var. *Williamsoniana*, Jones, op. cit. p. 117, pl. i. figs. 19, 20, and var. *Salteriana*, fig. 21, from Ardwick, Manchester, and Fifeshire; others are known from Edinburgh, Bristol, South Wales, Germany, Nova Scotia, and Illinois); but the sculpturing and ornamentation is, to all appearance, that of *Estheria*.

See on some Bivalved Entomostraca from the Coal-measures of South Wales, by Prof. T. Rupert Jones, Geol. Mag. 1870, Vol. VII. p. 214, Pl. IX. with figures of *Leaia*.

See also on the Occurrence of a Phyllopod genus, *Leaia*, in the Lower Carboniferous Rocks of Edinburgh, by R. Etheridge, jun. (Annals and Mag. Nat. Hist. 1879, th series, vol. iii. pp. 257–263).

The points of difference observable are, first, that the valves of "*Solenocaris*" appear to be longer and narrower than in *Helminthochiton*, and the lines of growth appear to be harder, sharper, and squarer, whilst the radiating ribs or striæ of the dorsal area are more numerous on the valves of the former than on those of the latter genus. In *Helminthochiton* the lines of growth observable upon the lateral areas of each valve are rather more curved and less quadrangular than in "*Solenocaris*."

Prof. Rupert Jones and Mr. Robert Etheridge, who have examined and compared the specimens from Thraive, and from Penwhapple and Balcletchie, are satisfied of their generic, if not of their specific identity. For differences above specified I prefer, on the whole, to treat them as distinct. Under these circumstances, it will be needful to refer them to *Helminthochiton* and to suggest a fresh specific name for the *Chiton* from Thraive, and I venture to propose to name it *Helminthochiton Grayiæ*, in honour of its discoverer, Mrs. Robert Gray, who has contributed so much to the elucidation of the fossil-remains from the Silurian rocks of Ayrshire, and to whom we are indebted for the opportunity of describing the present interesting specimen.

EXPLANATION OF PLATE IX. Figs. 7–12.

Fig. 7. *Helminthochiton Grayiæ*, H. Woodw. (side-view) natural size; *a.* supposed anterior or cephalic plate.
,, 8. ,, ,, ,, (dorsal view) ,, ,,
,, 9. Two of the valves of same, viewed dorsally, twice nat. size; *a*, *a*, position of *apophyses*, not clearly to be made out in the fossil.
,, 10. Side-view of a valve of same, enlarged twice nat. size.
,, 11. ,, ,, of *Helminthochiton* (*Solenocaris*) *solenoides*, Young and Young (twice nat. size).
,, 12. Two valves of *Chiton squamosus*, Lamk. (recent), placed for comparison with the fossil, viewed dorsally.

Figs. 7-10 from the Upper Bala Beds of Thraive, near Girvan, Ayrshire, in the collection of Mrs. Robert Gray, of Edinburgh.

IV.—The Classification of Stratified Rocks.

By Henry Hicks, M.D., F.R.S., F.G.S.

MR. JUKES-BROWNE'S proposed classification of our rock groups, in the July Number of the Geological Magazine, is a commendable attempt to solve an important question, especially where he proposes to establish divisions on palæontological evidence, in preference to depending upon minor breaks in the succession, which must always be more or less local.

In some respects, however, his table lacks the definite order and simplicity which should be the main point aimed at in any attempt at improving the classification.

All appear more or less agreed as to the great divisions, and the terms *Primary*, *Secondary*, and *Tertiary*, are on the whole satisfactory.

The subordinate divisions should as far as possible have Geographical terms with wide applications, but such names as Carboniferous and Cretaceous will also doubtless remain in use.

The wide geographical divisions should be divided and subdivided under more local names. The Lower Palæozoic rocks in the West of England and Wales could according to this plan be satisfactorily arranged as follows:—

I would apply the term *Cambrian* in a far more general sense than it has hitherto been used, and would place it as one of the main divisions of the Palæozoic, the others being *Devonian* and *Carboniferous*.[1]

Cambrian, being a term derived from the whole of the Principality of Wales, where the Lower Palæozoic rocks are best exposed, and in which every important group from the base of the Llanberis and Harlech series to the top of the Ludlow is found, is incomparably the best that can be suggested for this purpose.[2]

The Cambrian in this arrangement should be broken up into three primary divisions with the names in descending order of *Silurian*, *Ordovician*, and a new name *Georgian*, from the districts bordering St. George's Channel, where the lower rocks (Llanberis, Harlech, Menevian, etc.) are best exposed, and where they have been mainly examined. The groups and series should have local names—such names being taken from places where the beds were first examined, or are well exposed.

The following table will explain the arrangement suggested:—

SYSTEMS.	PRIMARY DIVISIONS.	GROUPS OR STAGES. (WALES, ETC.)	(SCOTLAND)	(IRELAND).
CAMBRIAN.	SILURIAN.	Ludlow	?	?
		Wenlock	?	?
		Llandovery	?	?
	ORDOVICIAN.	Bala	?	?
		Llandeilo	?	?
		Llanvirn	?	?
		Arenig	?	?
	GEORGIAN.	Tremadoc	?	?
		Dolgelly	?	?
		Ffestiniog	?	?
		Maentwrog	?	?
		Menevia (instead of Menevian)	?	?
		Solva	?	?
		Caerfai	?	?

ARCHÆAN, OR, PRE-CAMBRIAN.

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[1] It may be found advisable to class the Upper Palæozoic Rocks, like the Lower, into one system with three Primary divisions. In that case the term Devonian would be applied, in a better sense, as the lowest of the Primary Divisions in that system.

[2] The term Silurian may possibly occur to some as suitable, but to my mind it seems entirely out of the question, as comparatively only a few of the groups,—none indeed of the more important of the lower groups,—occur anywhere within the limited area formerly occupied by the *Silures*.

V.—NOTE ON THE GENERIC IDENTITY OF THE GENUS *ESTHONYX*, COPE, WITH *PLATYCHŒROPS*, CHARLESWORTH (=*MIOLOPHUS*, OWEN).

By R. LYDEKKER, B.A., F.G.S., etc.

IN an early number of the present serial[1] Prof. Sir R. Owen described and figured the hinder part of the palate of a small mammal from the London Clay of Herne Bay,[2] under the new name of *Miolophus planiceps*. The specimen is now preserved in the Museum at York, and had been previously described by Mr. E. Charlesworth[3] under the name of *Platychærops Richardsoni*; a circumstance which seems to have escaped the notice of Sir R. Owen. This name having the priority should supersede that of *Miolophus*.[4] The specimen (of which there is a cast in the British Museum) shows the second and third true molars of both sides, and on the right side the fourth premolar and the alveoli of $\underline{\text{pm 3}}$ and $\underline{\text{m. 1}}$. Both the later premolars and true molars are of the same general form, and have trituberculur crowns. Sir R. Owen regarded the specimen as indicating a form allied to *Hyracotherium* (including *Pliolophus*); but the similarity between the premolars and true molars and the trituberculate crowns of the latter forbids the acceptance of this view.

In 1874 Prof. Cope[5] founded a new genus, from the reputed Eocene of New Mexico, under the name of *Esthonyx*, the type species being named *E. Burmeisteri*. In two subsequent communications[6] the same writer determined the dental formula of this form to be I. $\frac{2}{3}$, C. $\frac{1}{1}$, Pm. $\frac{3}{3}$, M. $\frac{3}{3}$; and in the latter of the two he gives a reduced figure of the right half of the palate.[7] The third (penultimate) premolar has one external and one internal cusp, and is separated by a distinct interval from the teeth on either side. In the fourth premolar these cusps are much enlarged, and the tooth is transversely elongated. The true molars have two external cusps, which are flattened, close together, and well within the margin of the base of the crown. There is one internal cusp, and a strong posterior ledge.

This description applies word for word to the palate of *Platychærops Richardsoni*; and if the figure of the latter be compared with that of the so-called *Esthonyx Burmeisteri*, the close resemblance of the two will be self-evident. The European form exhibits the isolation of the alveolus of pm 3, and the marked contraction of the cranium at the level of this tooth.

The writer has, therefore, no hesitation in uniting *Esthonyx* with *Platychærops*. The American *P. Burmeisteri* appears to have been very nearly equal in size to *P. Richardsoni*, but is distinguished by the relatively smaller size of the last true molar.

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[1] GEOL. MAG. Dec. I. Vol. II. p. 339, Pl. X. Fig. 1 (1865).

[2] Erroneously stated to be from Sheppey.

[3] Rep. Brit. Assoc. for 1854, Trans. of Sections, p. 80. See also GEOL. MAG Dec. I. Vol. III. p. 48 (1866).

[4] The description is somewhat vague, and the two sides of the molars are reversed in the description.

[5] Rep. U.S. Geogr. Surv. W. of 100th Meridian, Vert. Foss. New Mexico, p. 6 (1874), 8vo.

[6] Proc. Amer. Phil. Soc. 1881, pp. 147-148; and Amer. Nat. 1884, pp. 479-480.

[7] A full-sized figure is given in Rep. U. S. Geol. Surv. vol. iii. pl. xxiv. C. fig. 1 (1884). 4to.

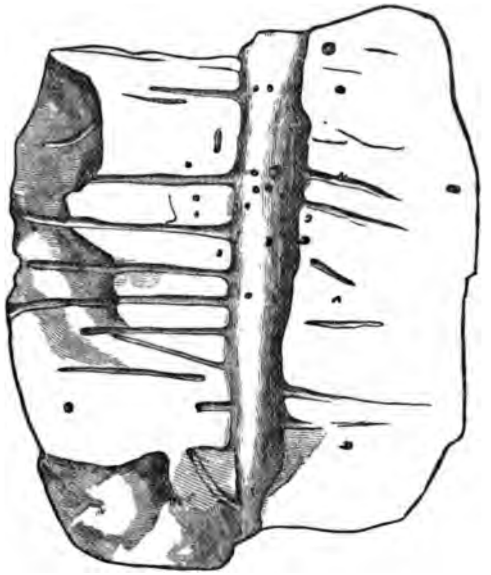
With regard to its serial position, the genus was originally referred by Prof. Cope to the Insectivora, but in his latest memoir[1] it is placed among his Creodonta, in the family *Leptictidæ*, which includes *Proviverra* (=*Stypolophus*, Cope, *Cynohyænodon*, Filhol).

Provisionally accepting this reference, the present writer will include *Platychœrops* in the group Carnivora Primigenia;[2] which appears to connect the true Carnivora by insensible gradations with the Insectivora. Prof. Cope suggests that the genus may be an ancestral form connected with *Erinaceus*.

VI.—NOTES ON FOSSIL ROOTS IN THE SARSEN STONES OF WILTSHIRE.

By WILLIAM CARRUTHERS, F.R.S., etc.

HAVING had placed in my hands by Prof. T. Rupert Jones (who has already communicated some notes on Sarsen Stones to your pages, Vols. for 1875 and 1876) some microscopic preparation of plant-remains found in Sarsen Stones from Wiltshire, belonging to



Impressions of Roots of a Palm (?), seen in a weathered Sarsen-stone in a wall at Abury (from a pencil-sketch by Major C. C. King).

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[1] Amer. Nat. 1884, pp. 347, 479.

[2] "Catalogue of Fossil Mammalia in the British Museum," pt. i. p. 20 (1885). The writer finds it will be necessary to issue a supplement to this part, as he is continually coming across specimens in the Museum which have hitherto been referred to other orders, but which he now finds should be included in those treated of in this part. He proposes (with the sanction of the Museum authorities) to issue this supplement on the completion of the Catalogue of the Ungulata.

Mr. Thos. Codrington, F.G.S.,[1] I would be glad to state in a sentence or two the results of my examination.

These vegetable remains are certainly *roots*. The method of branching shown in some of the specimens, and shown still better in a pencil-sketch by Major C. C. King, from a Sarsen which has been weathered in a wall at Abury, leave no doubt as to this. The rootlets leave the main root in every direction at right angles. The roots are in their original position. The soft sand, now indurated by siliceous cement, has been the soil on which the plants grew. An examination of the preparations shows the main stem to have been composed of a small central vascular bundle, surrounded by a considerable thickness of soft parenchyma, consisting of uniform cells of short rectangular shape. The cells have not been distorted by pressure, but retain the size and form of the original tissue,—which is a further evidence of the roots being preserved in the position in which they grew. There are not sufficient data in the specimens to enable one to determine with certainty what was the nature of the plants to which the roots belong; but it appears to me probable that they were monocotyledonous plants; and they may have been *Palms*, a group represented in the Eocene Flora of England.

NOTICES OF MEMOIRS.

Gastornis Klaassenii, Newton. A Gigantic Bird from the Lower Eocene of Croydon.[2] By E. T. Newton, F.G.S.

Mr. H. M. Klaassen, F.G.S., in his paper on the Series of Lower Tertiary Strata exposed in the railway cutting at Park Hill, near Croydon, read before the Geologists' Association (Proc. vol. viii. p. 226, 1883), mentions that he had obtained the remains of a very large bird which would as soon as possible be described. The description of these most interesting specimens has been delayed, in the hope that additional material might be brought to light, but as there seemed no longer any probability of other specimens being found, a full account of them, with detailed descriptions, was given in a paper read before the Zoological Society on the 5th of May last, and is in due course to appear in the Transactions of that Society. In the mean time the following account of the paper which is published with the assent of the President, Prof. Flower, may be of interest to the readers of the Geological Magazine.

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[1] In 1865 Mr. Thomas Codrington, C.E., F.G.S., described in a paper "On the Geology of the Berks and Hants Extension and Marlborough Railways," in the "Magazine Wilts Archæol. Nat. Hist. Soc.," 1865, the occurrence of fossilized vegetable tissue in the pipe-like holes traversing some Sarsen Stones lying on the ground westward of Little Bedwin. In the "Geological Magazine, new series, Vol. II. 1875, p. 589, Prof. Rupert Jones, noticed some similar tubular cavities in the Sarsen Stones near Frimley, Surrey, and in other geological formations; and in Geol. Mag., new series, Vol. III. 1876, p. 523, he described similar vegetable marks in the Greywethers or Sarsens of the Chalk Downs near Marlborough, and particularly in the enormous upright stones at Avebury (Abury). These and other similar markings seen elsewhere, are also alluded to by him in the "Trans. Newbury District Field-Club," vol. ii. 1878, p. 249, etc.

[2] Abstract of a paper read before the Zoological Society, May 5th, 1885.

These gigantic bird-bones were obtained from the "Blue Clay" and lignite patches of the Woolwich Beds, which lie immediately above the "Mottled Clays," and are marked *f* and *g* in Mr. Klaassen's section. The most interesting among these specimens are the portions of two large tibiotarsi and parts of a femur. The most perfect tibiotarsus when complete must have had a length of at least twenty inches, and its trochlear extremity is three inches and a half wide. Of the second tibiotarsus only the lower end is preserved, but this is larger, being a little over four inches wide. These bones resemble very closely the corresponding parts of *Gastornis Parisiensis*, but present differences sufficient to prevent their being referred to the same species, and they have therefore been named after their discoverer, *Gastornis Klaassenii*. This Eocene bird must have been as large and heavy in build as the *Dinornis crassus* of New Zealand.

The original specimen of *Gastornis* from the Lower Eocene beds of Meudon near Paris, was described by M. Hébert in the Comptes Rendus for 1855 (vol. xv. pp. 579 and 1214), and the genus named after their discoverer, M. Gaston. These Parisian bird-remains were afterwards more fully described and compared with recent forms by Prof. (now Sir Richard) Owen, in the Quarterly Journal of the Geological Society (vol. xii. p. 204, 1856), and by M. Milne-Edwards (Oiseaux Fossiles, vol. i. p. 165). Unfortunately the trochlear extremity of the tibiotarsus of *G. Parisiensis* was so badly preserved as to render the comparison most difficult and unsatisfactory. Other specimens referable to the same genus have since been discovered in Lower Eocene beds near Rheims, and described by Dr. Victor Lemoine under the name of *Gastornis Edwardsii* (Recher. Oiseaux Foss. envir. d. Reims, 1878 and 1881); these include parts of the head, vertebræ, etc., and are therefore extremely valuable; but the lower ends of the tibiotarsi are far from being well preserved, and consequently do not help us much in comparing this most important bone with the same parts in recent birds. Mr. L. Dollo, of the Brussels Museum, has described the distal end of the femur of a large bird which he has referred to *Gastornis Edwardsii*, Lemoine, from the Lower Landenien of Mesvin, near Mons, Belgium (Bull. Mus. Roy. Hist. Nat. Belg. tom. ii. p. 297, pl. xi. 1883).

These large tibiotarsi from Croydon have their distal ends so perfect that every detail of their structure can be studied. It is not a little remarkable that, in this part of its organization, *Gastornis* is quite unlike any of the large birds, recent or fossil, at present known; the living Ratitæ having a tibiotarsus quite unlike that of *Gastornis*; and that of *Dinornis*, although making a somewhat nearer approach, has the trochlear extremity of an entirely different type. Indeed, the known forms of Ratitæ all differ more from *Gastornis*, in regard to the tibiotarsus, than do some of the living Carinatæ; and it is interesting to find that opinions, expressed by some previous writers, as to the Anserine affinities of *Gastornis*, are confirmed by the detailed comparison with recent forms, which the more perfect Croydon specimens now render possible. Although the tibiotarsus of *Gastornis Klaasseni* more nearly resembles that of the Anserine than of any other form of bird, yet it differs in certain particulars from every genus with which it has been possible to compare it, and seems to represent an entirely new type. According to the researches of Dr. Victor Lemoine, *Gastornis*, in other parts of its organization, shows Ratite affinities. At present the median portion of the sternum is unknown; but the small size of the wings, in some species at least, leads one to expect that it will prove to be without a keel, and thus show a further resemblance to the Ratitæ.

REVIEWS.

I.—Russian Central Asia, including Kuldja, Bokhara, Khiva, and Merv. By Henry Lansdell, D.D. Two volumes. (London: Sampson Low & Co., 1885.)

IN these interesting volumes, describing a long and somewhat adventurous journey, Dr. Lansdell incidentally imparts to his readers a considerable amount of information on the Geology of Turkestan and some other parts of Central Asia, obtained partly by personal observation, partly by careful compilation from books and papers in languages other than English. The author's route from Sergiopol to the valley of the Ili, and thence to Chimkeut, ran in a general south-westerly direction. Near the first-named place he notes the occurrence of coal and graphite. Mesozoic and Tertiary rocks, from Triassic upwards, are then traversed, until on attaining higher ground Palæozoic and Metamorphic rocks are reached. The mountain ranges forming the huge *massif* of the Thian Shan are said to be largely composed of metamorphic and of various igneous rocks. Beyond the Ili the base of a chain composed of Palæozoic rocks with granite is skirted, and about Chimkeut many valuable minerals are found, such as rock salt and coal, besides iron, lead, silver, and even gold in workable quantities.

Not the least interesting part of the work is the author's description of the region south of the Sea of Aral from western Bokhara to the Caspian, the scene of some of the latest advances of Russia towards "the gates of India." Except for ulterior purposes, this enlargement of her empire does not seem one that need be envied. The region, as a whole, is singularly barren; not seldom a waste of shifting sands, among which the rivers lose themselves—thin beds, quite dry, or occupied only by shrunken streams, are frequently encountered, and Dr. Lansdell more than once calls attention to the impression, produced on his mind by the scenery, that he was travelling along the bed of a desiccated sea. At the present time he states that the Sea of Aral—many parts of which are extremely shallow—is distinctly drying up, and the effect of this on the country is very well described from the author's personal observation. His course for some 300 miles was down the Amu or Oxus, and he enters upon an interesting discussion as to the former variability of course of this river and the diversion of its waters from the Aral to the Caspian.

The book, we may add, contains even more information about the natural history and ethnology of the region traversed than it does about the geology, and is written throughout in a very pleasant style.

II.—The National Geological Surveys of Europe. By William Topley, F.G.S., etc. (1885, pp. 20.)

(Reprinted, with an Appendix, from the Report of the British Association for 1884, by permission of the Council. Trübner & Co. Price 6*d*.)

THIS pamphlet is a reprint, with some additions, of the Report read at Montreal and printed in the Geological Magazine for Oct. 1884. Additional information is scattered throughout the pamphlet; some, which seem the most important, are given below. The first Report of the Russian Survey for 1885 gave a full notice of the Report as printed in these pages, adding notes on the Surveys of the United States, Canada, India, Japan, etc.

Bohemia.—This is a section of the Austrian Survey, under the control of Anton Fritsch; the maps are those of the "Neue Special-Karte," scale 1 : 75,000, referred to in 1884. The text is included, as "Geologische Abtheilung," in "Archiv der Naturw. Landesdurchforschung von Böhmen," with plates and extra maps on various scales.

Hungary.—This Survey was established as a section of the Austrian Survey in 1868, but was soon after made a distinct body under the title "Königliche ungarische geologische Anstalt;" its head-quarters and the place of publication is Budapest. But it is in connection with the central institution at Vienna, and an abstract of its work appears in the Verhandlung.

The first director was Max von Hantken, who was succeeded in 1882 by Johann Böckh. The survey is done on the scale of 1 : 28,800.

The publications date from 1871. These are in Hungarian, but a German version is given in "Mittheilungen, aus dem Jahrb. k. u. geol. Anstalt," dating from 1872. About 22 sheets of the map are published.

Belgium. — Before the establishment of the existing Survey another had been in existence, conducted by a Committee of which M. Jochams was president. It was founded, in 1878, under the control of the "Ministère de l'intérieur;" this is stated on each publication, which may thus be distinguished from the publications of the existing Survey, the latter being headed "par ordre du Gouvernement."

About 20 maps were published (1879–81), each with text; 18 were by O. V. Ertborn and P. Cogels. Both Surveys have used the same topographical map.

Portugal.[1]—*Secção dos Trabalhos Geologicos de Portugal* (Lisbon).—This survey was commenced in 1857 (as Commissão Geol. de Portugal). It was reorganized with the existing title in 1869, under the direction of Carlos Ribeiro; he was succeeded, in 1883, by J. F. N. Delgado.

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[1] The first part of the serial publication of this Survey has just been issued—"*Communicações da Secção dos Trabalhos Geologicos de Portugal,*" tom. 1, fasc. 1, 1885; 8vo. Lisbon. Some of the papers therein contained had been previously printed.

The work is now done on the scale of 1 : 100,000; with occasional enlargements to double this scale. There are contours at intervals of 25 metres. The map will be in 37 sheets, longitude reckoned from Lisbon, 9° 9′ W. of Greenwich. The topographical map is not yet complete, and none of the sheets are published with the geology.

Several memoirs have been published, dating from 1865; and also a general map—"Carta Geologica de Portugal," by C. Ribeiro and J. F. N. Delgado, scale 1: 500,000; 1876 (now out of print).

PRUSSIA.—Geological surveys of some German States have been made on the scale of 1 : 50,000, not all directly by the Government; but the great survey previously described will probably absorb these, and will re-map the districts on the larger scale.

Amongst these local surveys are the following:—

BADEN, made by Zittel and Sandberger.

HESSE.—"Geologische Specialkarte des Grossherzogthums Hessen und der angrenzenden Landesgebiete." This survey, under the direction of R. Ludwig, is in eighteen sheets, with text. It was made by the "Mittelrheinischer Geologischer Verein" (Darmstadt), and was published from 1856 to 1872.

UPPER SILESIA.—A "Specialkarte der Oberschlesischen Bergrevier," scale 1: 10,000, is published by the "k. Oberbergamt in Breslau," in "Lieferungen," of ten or more sheets. The price of each sheet is 1½ mark.

ROUMANIA.—(*Biuroului Geologicŭ Romănŭ*, Buchurest). Established in 1882, under the direction of Gregoriŭ Stefănescu, for the purpose of providing materials for the International Geological Map of Europe. One Report has been published ("Anuarulŭ Biuroului Geologicŭ," anulŭ 1882–1883, No. 1, pp. 114, 1884). The rocks contained within the kingdom, which are briefly described in this Report, are:—Crystalline Schists (Archæan), Jurassic, Eocene, Miocene, Pliocene and Quaternary. This Report contains descriptions, with analyses, of mineral springs.

RUSSIA.—This survey[1] was commenced in 1882; the director is B. Cheresheff.

The publications comprise Reports in 8vo., and Memoirs in 4to.; the latter are illustrated by maps and plates; some of the Memoirs are descriptive of sheets of the maps, others of certain formations in various districts.

The Reports are in Russian only; the Memoirs have title in French ("Mémoires du Comité géologique"), and a translation or précis in German.

The map is on the scale of 1 : 420,000; to be completed in 154 sheets; 3 sheets are published. The meridian is Pulkowa, 30° 19′ E. of Greenwich.

The map has explanations and title in French:—"Carte Géologique générale de la Russie d'Europe."

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[1] For descriptions of this Survey, and of its publications, see *Nature*, vol. xxix. p. 93; xxx. p. 608; GEOL. MAG. Dec. III. Vol. I. p. 84, 1884.

A map of the Urals, prepared by the mining engineers, has been published by A. Karpinsky—"Geologische Karte des Ostabhanges des Urals," 3 sheets, 1884. Scale 1 : 420,000; with enlarged parts of 1 : 210,000.

APPENDIX. GEOLOGICAL MAP OF EUROPE.—Although only a small area of Europe has yet been published by the Surveys described above, enough is now known of its geological structure to justify the preparation of a complete map, on a scale sufficiently large to allow all the main subdivisions to be shown. This task has been undertaken by the International Geological Congress, which, during its meeting at Bologna in 1881, appointed a Committee to carry out the work. The Committee is formed as follows:—

For Germany . . .	E. Beyrich W. Hauchecorne	Directors of the Map.
,, Austro-Hungary .	E. Mojsisovics	
,, France . . .	A. Daubrée	
,, Great Britain . .	W. Topley	
,, Italy . . .	F. Giordano	
,, Russia . . .	A. Karpinsky	
	E. Renevier, Secretary.	

The map will be in 49 sheets (7 by 7), measuring in all about 12 feet by 10 feet. The scale is 1 : 1,500,000 (about 23½ miles to one inch). The expense of producing this Map is far beyond the means of the Congress; it was therefore resolved to apply for assistance to the various Governments of Europe. In most cases the money required was immediately promised, and in others satisfactory arrangements for the amount required have been made. England's share of the expense is £400, yearly instalments of which have been given, as required, by the Royal Society from its Government Grant. For this sum 100 copies of the Map will be returned.

The Map is being prepared at Berlin, and will be published there by Reimer & Co. A new topographical map is being prepared by Prof. Kiepert. Streams and railways are given in detail; in selecting the names of places special care is taken to mark those of geological interest or importance; the names of mountain-chains and chief hill-ranges are given, the heights of the summits being marked in metres. The meridian is Paris, 2° 20′ E. of Greenwich. The topography is far advanced, and much progress has been made with the geology.

The subdivisions represented on the Map will probably be nearly as follows: — Alluvium and Quaternary, Pliocene, Miocene, Oligocene, Eocene, Cretaceous (3 divisions), Oolite (2), Lias, Trias (2), Permian (2), Carboniferous (3), Devonian (3), Silurian (2), Cambrian, Crystalline Schists etc., (perhaps 2), Granite, Eruptive rocks (perhaps 6 or 7).

The geological information, as supplied by the various members of the Committee, is inserted under the supervision of W. Hauchecorne, the Director of the Geological Survey of Prussia; whatever success may attend the work will be mainly due to his energy and care.

III.—THE OLD RED SANDSTONE VOLCANIC ROCKS OF SCOTLAND. By B. N. PEACH and J. HORNE. [Trans. Roy. Soc. Edinburgh, Vol. XXXII. Part II. pp. 359–388.]

THE authors observe that the most interesting feature connected with the Old Red Sandstone formation in Shetland is the evidence of prolonged volcanic activity in those northern isles. The records of this activity are mainly confined to the west and north-west portions of the Mainland and the islands adjoining the western seaboard. They may be grouped into two divisions,—first, the contemporaneous igneous rocks, comprising the lavas and tuffs which were erupted and spread over the sea-floor during the accumulation of the sedimentary deposits; second, the intrusive igneous rocks, which were injected at a later date, probably towards the close of the Old Red Sandstone period in Shetland. In the peninsular tract of Northmavine, west of Hillswick, there is an important development of ancient lavas and tuffs, which attain a thickness of not less than 500 feet. The absence of any intercalations of sandstones, flagstones or shales, save near the fault at Brei Wick and Rooeness Voe. indicates that the subaqueous eruptions must have been well-nigh continuous for a time in that portion of the basin.

On the eastern seaboard the following order of succession in the strata was established:

5. Flaggy series of Bressay and Noss, consisting of alternations of sandstones, flags, and shales. At the base of Noss Head there is a zone of dark calcareous shale with limestone nodules, which has a striking resemblance to the well-known fish-bed of the Moray Firth basin.
4. Lerwick series, consisting of massive false-bedded sandstones, which throughout are markedly conglomeratic.
3. Rovey Head conglomerates.
2. Brenista series, consisting of well-bedded red flags.
1. Basement breccia.

Observations on the microscopic characters of the rocks show that the porphyrite and diabase lavas of Shetland are akin to the great volcanic series of Lower Old Red Sandstone age in Central Scotland.

Two beautifully executed chromolithographic plates of rock-sections, and a geologically coloured map of the Shetland Islands accompany this memoir, which is also illustrated by fourteen woodcuts in the text.

IV.—WALKS IN EPPING FOREST. Edited by PERCY LINDLEY. [The Geology of the Forest-District, by HORACE B. WOODWARD, F.G.S., of the Geological Survey of England.] London: 1885, long 8vo. with 36 illustrations and a folding-map. Sold at 123–125, Fleet Street, E.C., and at all Booksellers.

HAVE you ever been to Epping Forest? If you have not, it is certainly worthy of a visit. Just imagine! that in 1885 there actually exists, within half an hour of the Bank of England, an area of nine square miles in extent, which, by the munificence of the Corporation of the City of London, and at a cost of over a quarter of a million, has been secured as a place of recreation and enjoyment for the public for ever. This district, moreover—notwithstanding all the cruel curtailments it has suffered—is actually a bit of primæval forest land, and is the last remnant of the great forest of Essex, once extending over the whole county. Here in the merry months of May and June—especially in the middle of the week (avoiding the period embraced from Saturday to Monday)—one may hear the pleasant harmony of the thrush, the blackbird, the lark, and the linnet, with all the finches for chorus; whilst a host of rare birds may be seen by the early riser, who knows their haunts, who may watch the kingfisher by the brook, or listen to the entomologising woodpecker, or discover the heron knee-deep in some rushy pool.

Then too there are the wild animals. The fallow-deer (*Cervus dama*) have never been entirely exterminated, and are now on the increase. They are said to be lineally descended from the primitive stock first introduced by the Romans into Essex, and to differ from those preserved in other park-lands elsewhere.

The Red-deer (*Cervus elaphus*), and the Roe-buck (*Cervus capreola*), have both been re-introduced. These deer were abundant in this very district in prehistoric times, and probably down to the 17th century, if not later. The other denizens are hares, rabbits, foxes, badgers, pole-cats, martens, and some lesser forms of *Mustelidæ*.

In prehistoric times, as we know from the excavations at Walthamstow (see GEOL. MAG. 1869, pp. 385-388), we had in addition to the above, the Wolf, the Beaver, the Wild-boar, the Elk, wild Oxen, and Goats. In Pleistocene times we had a still larger number of forms which are now extinct or exterminated in this country, comprising *Elephas primigenius*, *E. antiquus*, *Spermophilus*, sp., *Rhinoceros tichorhinus*, *R. megarhinus*, and *R. leptorhinus*; *Hippopotamus major*; *Bison priscus*; *Bos primigenius*; *Ovibos moschatus*; *Cervus megaceros*, *Cervus tarandus*; *Felis spelæa*; and many others.

The forest then of to-day has a wonderful history of its own; going back through Historic, to Prehistoric times, and thence to the Pleistocene period, we can trace, by means of the peat-deposits, the Alluvium and the Brick-earth, one fauna as it succeeds another, marking not only great changes in the animals, but also in the climate and physical conditions of the district.

Mr. Horace B. Woodward, F.G.S., in his excellent sketch of the Geology of the Forest-area, takes us even beyond this point, to the Boulder-Clay, the Glacial Deposits, the Bagshot Beds and the London Clay; we cannot however give a fuller notice of this Guide here, but all who take an interest in the suburbs of our great Metropolis will secure a copy of this excellent little Guide for themselves. The illustrations are charming, and give an admirable idea of the beauty of the scenery of this delightful suburban resort.

V.—MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA. PALÆONTOLOGIA INDICA.

1. INDIAN PRETERTIARY VERTEBRATA, Series IV. Vol. I. Part IV. THE LABYRINTHODONT FROM THE BIJORI GROUP. By R. LYDEKKER, B.A., F.G.S., F.Z.S. Royal 4to. pp. 16, with 4 Plates. 1885.

AS far back as 1865, Prof. T. H. Huxley described the remains of *Dicynodon orientalis*, Huxl., and of *Gonioglyptus longirostris*, Huxl., from the Panchet group, Damúda series, Gondwána System of India.[1] These basal rocks of the secondary section, which may be considered homotaxial with the Triassic or Permian rocks of Europe, have also by their fossil remains an affinity with the Reptiliferous Triassic deposits beds of South Africa.[2]

Mr. R. Lydekker in the present memoir makes us acquainted with a new and very interesting form of Labyrinthodont reptile from Bijori, in the Central Provinces, for which he has proposed the genus *Gondwanosaurus*, with the trivial name of *Bijoriensis*. The specimen comprises the skull and a considerable portion of the axial skeleton; most of the bones have disappeared and are represented by moulds or cavities in the sandstone matrix. The skull agrees very closely in general size with that of *Loxomma Allmanni*, Huxl., from the Coal-measures of Northumberland (see Ann. and Mag. Nat. Hist. ser. 4, vol. xiv. pl. iv.), and it may be assumed that the present specimen indicates an animal of about the dimensions of that species. The structure of the teeth, the presence of epiotic bones, of a parietal foramen, and the structure of the thoracic shield, leave no doubt of the labyrinthodont nature of the specimen.

"*Gondwanosaurus* is evidently a more specialized type than *Archegosaurus*, although, if the occipital condyles were really absent, it agrees with the family *Archegosauridæ*, and differs from the *Actinodontidæ*. The specialization indicates an approach to the higher labyrinthodonts like *Mastodonsaurus*, and *Labyrinthodon*; this being marked by the presence of large tusks in both jaws within the outer series (a character which is common to several of the American *Actinodontidæ*), and of the inner articular buttress to the mandible. The absence of a post-articular process to the mandible is a character in which it approaches *Loxomma*; and it is thus easy to see how the higher forms have been derived from the primitive *Archegosauria*. If *Rhytidosteus* belong to the section, it indicates still more completely the transition, since the structure of the teeth is almost precisely intermediate between that of *Actinodon* and *Archegosaurus* on the one hand, and *Mastodonsaurus* on the other. The anchylosis of the mandibular symphysis (which, it may be remarked, is a very characteristic feature of the Crocodilia) in *Gondwanosaurus* is unknown among all the large European labyrinthodonts of which the mandible is figured, although it occurs in *Rhytidosteus*; it is not mentioned whether it is found in any of the

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[1] See Palæontologia Indica. series iv. vol. i. pt. 1, 1865, pp. 24.

[2] See papers by Dr. Ottokar Feistmantel on the Gondwâna Series of India, GEOL. MAG. 1876, Decade II. Vol. III. pp. 481-491, and Vol. IV. 1877, pp. 188-189.

American forms. Finally, there can be but little doubt from its general structure that *Gondwanosaurus* was an aquatic form."

"The range in time of *Archegosaurus* is given in the British Association Report for 1874 as exclusively Carboniferous, but *A. Decheni* and *A. latifrons*, Geinitz, have been subsequently described from the Lower Permian (Rothliegendes). *Zygosaurus* ranges from the Lower to the Upper Permian. The European *Actinodontidæ* are all of Lower Permian age; while the American forms are likewise referred to some part of the same period. *Platyops* is from the Upper Permian. The more specialized *Rhytidosteus* is said to be from Triassic strata; but there are good grounds for believing the formation in which it occurs to represent more than one European geological period, and its age may probably be given as somewhere between the Permian and Jurassic; it is said to come from beds lower down in the series than those which have yielded the mammalian *Tritylodon*.

Judging from the foregoing, the age of *Gondwanosaurus* should probably be (homotaxially) Permian; since the balance of evidence is in favour of regarding the Panchet group, which immediately overlies the Bijori group in which *Gondwanosaurus* was found, as of Triassic age, the Permian age of the Bijori group would accord well with this reference. On the other hand, however, the labyrinthodont *Brachyops laticeps* from the Kámthi (Mángli) group, which, like the Bijori group, belongs mainly to the Upper Damúda series, is allied to a European Jurassic form (*Rhinosaurus*), while the flora of the Damúdas has in many respects a decidedly Mesozoic facies. What is already known of the distribution of fossil floras in other parts of the world does not, however, forbid the view that the Damúdas as a whole, may correspond to the Upper Palæozoics, with a possibility of their upper beds being Lower Triassic; and on this view the occurrence of a Labyrinthodont allied to a Jurassic form should probably be taken to indicate that this group originated at an earlier period in India, while the primitive notochordal forms were still in existence. Judging from the degree of the specialization of *Rhytidosteus*, the strata in which it occurs might be best referred to the Trias, and preferably to the lower part of that period; but the points already mentioned show the necessity of the extreme caution which must be exercised in correlating strata from the occurrence of a single terrestrial form. In view of this necessity all the above suggestions as to the age of the Damúdas must be regarded as purely provisional."

2.—INDIAN TERTIARY AND POST-TERTIARY VERTEBRATA. SERIES X. Vol. iii. Part 6. SIWALIK AND NARBADA CHELONIA. By R. LYDEKKER, B.A., F.G.S. With 10 plates, pp. 56. (Calcutta, 1885. Royal 4to.)

MR. LYDEKKER has rendered this a most valuable memoir upon a very difficult group of vertebrate remains, the literature of which is exceedingly scattered.

Many examples of the fossil Tortoises and *Emydæ* are only preserved in a very fragmentary condition, and as the shells exhibit only the boundaries of the bony scutes and not those of the epidermal plates, and as in recent species, as a rule, the former are not described and are invisible without the removal of the overlying plates, it is in such cases almost impossible to determine the affinities of the fossils.

The great similarity in the shells of many existing emydines, and the doubt still existing as to the number of species, likewise renders the specific determination of their fossil allies a matter of extreme difficulty.

The comparatively small number of forms described when taken in connexion with the large number belonging to particular groups indicates that we are at present only acquainted with a small moiety of the whole Siwalik chelonian fauna; and from the extremely interesting nature of the species that are known to us, the attention of collectors may be particularly directed to the acquisition of additional specimens. Most of the species of Fossil Tortoises from the Siwaliks exhibit an intimate affinity with those now inhabiting India, and afford one of the strongest arguments for the late geological age of these deposits.

The following is a summary of the genera and species described by Mr. Lydekker in this Memoir :—

Family I. TESTUDINIDÆ.
Genus 1. *Colossochelys atlas*, Falc. & Cautl. (4 other species described, but not named).
Family II. EMYDIDÆ.

Genus 1. *Clemmys*,	sp. 1.	*C. sivalensis*, Theo.
	2.	„ *hydaspica*, Lyd.
	3.	„ *Theobaldi*, „
	4.	„ *punjabiensis*, Lyd.
	5.	„ *sp. indet.*
	6.	„ *palæindica*, Lyd.
	7.	„ *sp. indet.*
Genus 2. *Pangshura*,	sp. 1.	*P. flaviventris*, Günth.
	2.	„ sp. indet.
3. *Batagur*,	sp. 1.	*B. Falconeri*, Lyd.
	2.	„ *Bakeri*, Lyd.
	3.	„ *Durandi*, Lyd.
	4.	„ sp. indet.
	5.	„ *Cautleyi*, Lyd.

Family III. TRIONYCHIDÆ.

Genus 1. *Emyda*,	sp. 1.	*E. vittata*, Peters.
	2.	„ *lineata*, Lyd.
	3.	„ *Sivalensis*, Lyd.
	4.	„ *palæindica*, Lyd.
Genus 2. *Trionyx*,	sp. 1.	*T. Gangeticus*, Cuvier.
	2.	„ sp. indet.
	3.	„ sp. „
Genus 3. *Chitra*,	sp. 1.	*Ch. indica*, Gray.

The ten plates which illustrate the work are in every way worthy of so excellent a monograph, and reflect the highest credit upon the artist.

VI.—GEOLOGY OF SOUTH AUSTRALIA.

1.—NOTES ON THE ECHUNGA GOLD-FIELD. By HENRY Y. LYELL-BROWN, F.G.S., GOVERNMENT GEOLOGIST. With a coloured Geological Map. (Adelaide, 1885.)

IN these Notes, Mr. H. Y. L. Brown has gathered together all the available information about Echunga, a gold-field which appears to have been first noticed in 1852, a year after the discovery of such marvellously rich auriferous deposits in the adjacent Colony of Victoria, which has since become so famous for its gold-fields.

The district of Echunga does not appear to have ever realized the ardent expectations of those whose only ambition seems to be to get rich in haste. Between 30 and 40 claims have been taken up and worked, sometimes by individuals, sometimes by companies; the Government appears also to have employed the services of prospectors and to have paid over £1000 in bounty money to successful explorers.

No regular returns seem to have been kept, and after a reef or gully proved unprofitable, it was abandoned, and no record left of the actual results. It is, however, believed that the total amount of gold raised since 1852 has been large.

1. Most of the area (about ten miles long by six miles wide) is composed of Lower Silurian rocks consisting of conglomerates, grits, quartzites, sandstones, clay-slate, micaceous-slate and sandstone, mica-schist, etc., with accompanying felspathic decomposed dyke-like masses, and decomposed greenstone and granite veins.

In this the quartz-reefs and payable gold-diggings occur, extending for nearly the entire length of the area.

2. Sands, clay, gravel and conglomerate of Pliocene age and of variable thickness compose the *Older Gold Drifts*, and occupy a very considerable area in the central, western, and southern parts.

3. A smaller area is covered by cappings of sand, clay, gravel, etc. (generally at a higher level than the alluvium), believed to be of Newer Pliocene age. These deposits occur along the river at various places, having apparently escaped being denuded off. They form the *Middle Gold Drift*.

4. Lastly, the gullies and flats are occupied by alluvium, clay, sand, gravel, etc. This forms the *Upper Gold Drift* of Post-Pliocene age. Mr. Brown observes that besides the auriferous channels gutters, and basins which have been worked out here, it is probable that many others exist, which can only be discovered by sinking trial-holes here and there, where the ground has not previously been prospected.

In the case of the large Tertiary valley which extends from near Hahndorf southwards in the direction of Meadows, and which is wider and deeper and at a lower level, it is probable that much water would be met with in sinking in the deep ground. To prove it, a series of shafts should be sunk across the valley, so that the position and nature of the deep ground might be ascertained. Judging by the character of the rocks forming the ranges bounding this area, and the auriferous nature of the country generally, there is every reason to expect that a payable auriferous lead exists here.

The Map which accompanies this Memoir is a large one (scale 80 chains=1 mile)—about two inches to a mile—and is very carefully executed, and well suited to the needs of a large mining district. A very full list of references to exact spots at which the rocks and minerals have been examined and determined accompanies the map.

2.—REPORTS ON GEOLOGY OF COUNTRY EAST OF FARINA AND NORTHWARD TO LAT. 23° 10′. By HARRY P. WOODWARD, F.G.S., Assistant Government Geologist. With a Route-Map from Farina Town through a portion of Queensland to Adam Ranges in the Northern Territory.

THIS consists of an itinerary, with jottings by the way for upwards of 600 miles, during a trip to the North with the Queensland Boundary Survey Party from Farina to about lat. 23° 15′, showing the route traversed by the party from December, 1883, to September, 1884.

The country appears to be for the most part very uninteresting, geologically speaking, consisting of stony flats, and stony plains, varied by stretches of say 160 miles of nothing but sand-hills and flats running north 20° west, about two to the mile, and from 50 to 100 feet in height. In other parts the sand-hills are varied by flat-topped table-hills, and occasionally wide tracts of flooded plains; then for variety more sand-hills, then more clay flats strewn with stones of desert quartzite, and then again more sand-hills.

A fine water-hole with sweet drinkable water seems to be the highest luxury the country affords. Many of the wells and water-holes are brackish, and nearly all contain so considerable a percentage of saline ingredients as to render them at first unpleasant to the taste, and nauseous to the stomach.

The Secondary formation found near Farina and the north end of the range generally, continues north for about 150 miles from the east and west Boundary line, and the rocks are mostly ferruginous sandstones and quartzites, white felspathic quartzose sandstone, pipe-clay, and blue clay, overlain by Tertiary table-hills of Jasper-rock ("desert quartzite") with gypseous marls, marlstones, and clay, also the newer or Post-Tertiary sandhills, drifts, and clays.

The sandhills appear to derive their origin from the weathering of the Tertiary and Jasper-rock, with which all the clay-flats are strewn, most probably whilst this country was under the action of waves in a shallow sea; the salt also seems to point to the same conclusion.

The direction of the sand-hills is apparently governed by the wind, as sand has always a tendency to form in ridges at right angles to the prevailing winds, and generally travels before it, as these hills are evidently doing, although very slowly, being very steep on the east side, whilst the west rises with a gradual slope; their motion is, however, greatly checked by vegetation, which is pretty thick on their slopes. This wind action is also the cause of the height of the sand-hills, as the wind piles the sand from the flats up the gently-rising western acclivity, but does not so rapidly force it down over the eastern slope.

In a second short "Report on the Mines. Hills, etc., of the Range to the east of Farina and Leigh's Creek Railway Station," mention is made of "Mount Babbage," etc., from whence the Cycadean remains recorded in our last number (GEOL. MAG. July, pp. 289-293, Pl. VII.) were obtained.

"There are," writes Mr. H. P. Woodward, "one or two patches of the Tertiary and Secondary formations left as 'outliers,' capping some of the hills, as *Mount Babbage* and the *Cutaway Hills*; also a small patch near Mount Fitton, which is all that is left of what once filled the basin here. The plains which flank the ranges to the north, east, and west are of Secondary age, and consist of clays with Tertiary table-hills of quartzite and gypseous marls." This country seems to offer some opening prospect in the future to the miner; several copper-mines actually exist among the hills, and there seems to be a fair supply of drinkable water, but whether sufficient for mining purposes on any large scale seems doubtful.

VII.—FAUNA DER GASKOHLE UND DER KALKSTEINE DER PERMFORMATION BÖHMENS VON DR. ANT. FRITSCH. Band II., Heft. I. Prag, 1885. Published by the Author. (Sold by Fr. Řivnáč. London: Trübner and Co.)

IN some introductory remarks the author states that the second volume will be largely devoted to Amphibians in which the teeth show a labyrinthic structure. From the circumstance that these remains are more disconnected, they are often determined with difficulty. The teeth exhibit two principal types, first, that in which the plication is simple and rather irregular; and secondly, that which has a typical labyrinthic structure. The characters of the vertebral column are less easily classified; and the vertebræ are not always ossified and preserved. Dr. Fritsch offers some critical remarks on Cope's classification of vertebral characters, observing that even in *Archægosaurus* the thoracic vertebræ are rachitomous, while the caudal vertebræ are embolomerous; so that the two groups *Rachitomi* and *Embolomeri* appear to be founded on characters of different parts of the same vertebral column.

The volume opens with some account of the Dendrerpetontidæ. The Bohemian species of *Dendrerpeton* are all new, and are named *D. pyriticum*, *D. foveolatum*, and *D.? deprivatum*. *Dendrerpeton pyriticum* is known from skulls which are 53 mm. long, and 48 mm. wide. The orbits are subcircular, nearly midway in the length of the head, and separated from each other by more than an orbital diameter. The foramen parietale is one millimètre long, and is in the middle of the length of the parietal bones. The nares are not shown. The bones of the upper surface of the skull are ornamented with small pits and radiating grooves. The premaxillary bone carries six rather long slender teeth, which are curved backward, and are two and a half times as long as the base is broad. The base has about 14 furrows. The maxillary bone is half as long as the skull, and carries from 17 to 20 teeth, which become smaller from the front backward, so that the sixteenth is only half as long as the first. The nasal bones are the longest median bones in the roof of the skull. The processes which are analogous to occipital condyles, the author regards as processes of the supra-occipital bones or capable of being otherwise interpreted.

On the palate, the large vomerine bones unite with the premaxillaries. In the anterior third of the vomer is a single strong tooth with a small tooth behind it. The palatine is imperfectly preserved. The slender anterior part which is alone known has a single furrowed tooth as large as those in the premaxillary. The pterygoid is also badly preserved: there are traces of denticulation on its hinder border. The parasphenoid is remarkably small, with the shield deeply notched on each side and the median spine short. The anterior half of the shield shows close-set marks of attachment for small denticles.

Dendrerpeton foveolatum has a shorter and broader skull. The bones of the head are marked with punctations as though made with a needle. The lower jaw appears to carry 30 teeth, with a large tearing tooth in front.

Dendrerpeton deprivatum is known from a skull five centimètres long, which is nearly as long as broad, and triangular in form. The orbital circles are one and a half times their diameter apart, and in the middle of the skull. The upper bones of the head are pitted with little holes, which, when magnified, resemble those of the crocodile, but there are also more minute pittings on the elevated interspaces. On the hinder border of the orbit the post-orbital bone shows a porous character. An extra bone occurs between the post-frontal and squamosal, and is regarded by the author as a dismemberment of the squamosal. The parietal bones are relatively long, and reach forward to between the middle of the orbits.

The family Diplovertebridæ includes amphibians of similar aspect to *Dendrerpeton*, with caudal vertebræ which consist of two segments, the anterior of which carries the neural arch and the ribs, while the posterior part is merely a similar vertebral body without processes. The skull-bones are not pitted, and their only ornament is radiating lines on each bone. This type is only known from one species, which was about half a mètre long.

Diplovertebron punctatum. The skin was defended on the abdominal surface by long scales, but there is no proof that the back was armoured. The premaxillary bone carried five curved teeth. They are twice as long as broad. There are 23 teeth in the maxillary bone, and the first two are rather stronger than the others, which show no decrease in height as they extend backward. They are three times as long as wide, and distinctly furrowed in the lower third. In the lower jaw the teeth are much smaller, and number 44. The first seven are the longest, and the third tooth is the strongest in the lower jaw. In both jaws the teeth seem to have an alternating arrangement, so as to be approximately in two parallel rows. The vertebræ have the bodies but very slightly cupped. The author accounts for the double body by supposing that the inter-vertebral portion of the notochord has persisted and become separately ossified. The accessory centrum is as large as the principal centrum. The ribs are thin and angularly bent in their upper third; in large specimens both capitulum and tuberculum are seen. The pelvic girdle is well developed.

The author is uncertain whether the Archægosauridæ is represented in Bohemia; but his studies of German specimens, embodying conclusions similar to those presented by Gaudry to the Geological Society of France, show that the vertebræ of the thorax consist of four pieces which may be named neural arch, two lateral ossifications termed pleuracentra, to which the ribs are attached, and an inferior median piece, the hypocentrum. Young individuals show no trace of these elements, so that the vertebral column is inferred to have been notochordal. The upper arch ossified first, and then the hypocentrum. In the caudal vertebræ the hypocentrum is large and well developed, while the pleuracentra seem less perfectly ossified, and in the position of the normal centrum. The Bohemian specimen which most resembles *Archægosaurus* the author describes as *Sparagmites lacertinus*, though recognising that it were preferable to leave them unnamed on account of their fragmentary character. These remains indicate an amphibian 40 or 50 cm. long. The caudal vertebræ show the neural arch and rib to be well ossified, but the elements of the centrum are imperfectly ossified.

The genus *Loxomma* is represented by a jaw and teeth described as *L. Bohemicum*. *Chelydosaurus vrani* is a powerful amphibian, about a mètre long, much resembling *Archægosaurus*, but with the vertebral column better ossified, with the ribs expanded at their distal ends, and the tarsus well developed. It has the aspect of a half-grown Crocodile, the head being relatively large; and the tail is apparently longer than the body. The longest skull is 14 cm. long and 12 cm. broad. The longest thorax is 48 cm. long and 15 cm. broad. The back yields no indication of armour, but the abdominal shield is well developed. It consists of 64 rows of plates, arranged obliquely, with six to eight plates in each row. Some scales show signs of wear during life, as though by the animal crawling over stones and sand. The scales are three times as long as broad, and the rows they form have almost the aspect of ribs, which is remarkable, because their mode of union in the median line offers a form which is only comparable to the capitulum and tuberculum of the rib. Besides this abdominal armour, in which the rows of scales are directed backward, there are on each side of the median thoracic plate about eight rows of scales, which are directed forward.

The snout appears to elongate with age, and in this character resembles *Archægosaurus*. The orbits are oval, and behind the middle of the length of the skull. The parietal foramen is small, and far behind the eyes. The bones of the upper surface of the skull are wrinkled and puckered rather than pitted, so that the sutures between the bones are made out with difficulty. The premaxillaries carry about six blunt cylindrical teeth. There are two circular depressions in the hinder portions of these bones, which are regarded as narial. The maxillary bones extend backward almost to the orbits, and carry 25 teeth, of which those in the middle portion are largest. The nasal bone is twice as long as broad, but appears to increase in relative length with age. The frontal bone is twice as broad in front as behind, and four times as long as wide in the middle. The post-orbital bone forms the external border of the orbit, excluding the jugal, meeting the prefrontal in front, and the post-frontal, squamosal and supra-temporal behind. The jugal is greatly elongated, reaching forward with the maxillary to the anterior angle of the nasal bones, and backward to the end of the maxillary bone behind the orbit. The parietal bone is remarkably small, being only one-fifth the length of the skull. The epiotic bone terminates posteriorly in a blunt point. The supra-temporal bone is very large, and forms nearly a third of the hinder part of the skull. The quadrato-jugal is longer than the supra-temporal, and margins it externally. The condition of the condyle is not quite clear, but the condyle is apparently bilobed, and there is no evidence that the basi-occipital enters into it. In the lower jaw there were 25 to 30 slender teeth, with furrows at the base.

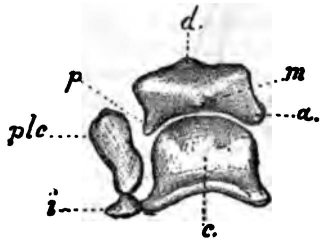
The vertebral column includes 23 vertebræ in the thorax, two in the sacrum, and about 35 to 40 in the tail. The large hypocentrum of the vertebra is constricted in the middle like a dice-box, and is deeply cupped for the unossified part of the notochord. The pleuracentra are small ossifications at the sides, seen in both the thoracic and caudal vertebræ. Below these ossifications, and between the hypocentra, are small hypocentra-pleurale. In the caudal vertebræ these latter ossifications appear as inferior spinous processes. The author traces the modifications of these vertebral elements in the several regions of the vertebral column; and shows that the pleuracentrum in the caudal vertebræ of this genus is not placed between the hypocentrum and neural arch, as in the figure of *Euchirosaurus*, given by Gaudry, but is placed between two neural arches, in a way, we may remark, that becomes more intelligible from Professor Hasse's researches on Elasmobranch fishes. The author is disposed to appeal to the keeled leaf-shaped inferior processes of the vertebræ as throwing light upon the keels in the caudal vertebræ of crocodiles. But those processes might be appealed to in elucidation of the chevron bones; and the keels on the crocodilian caudal centrum are readily comprehended as the longitudinal extension of the chevron facets consequent upon the increase in size of the vertebra with age.

The ribs are thickened at the proximal end, without definite capitulum and tuberculum, rounded and flattened at the distal end, and never longer than four times the length of the vertebra. In the sacral region the ribs become transformed into powerful transverse processes like those seen in *Melanerpeton* and *Sphenosaurus*, and comparable to the structures seen in young crocodiles and *Chelydra serpentina.*

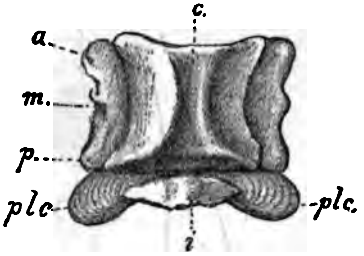
The clavicle is a long stalk-shaped bone placed anterior to the coracoid. The coracoid is expanded. subtriangular, with a posterior stalk process. Between the coracoids is the rhombic-shaped interclavicle. In the restoration a scapula is shown extending dorsally over the ribs.

The fore arm is shorter than the upper arm. There are five digits in which the number of bones is 1, 2, 3, 2. 1. The pelvis consists of three bones on each side, which are united into an os innominatum, and are about equally long. The ilium is small and elongated. It joins the ischium behind, and from the point of union a small forwardly directed pubis is given off. The hind limb is large and well preserved. The tibia and fibula are both remarkably widened at the distal end. The tarsal bones are few in number; astragalus, calcaneum, and two tarsal bones of the second row are identified. There are five digits in which the number of phalangeal bones is 1, 2, 3, 4, 3.

Sphenosaurus Sternbergii (Herm. von Meyer). The skull in this type is unknown, and the skeleton described has already been treated of by Fitzinger and von Meyer. It consists of 18 thoracic vertebræ, sacral vertebræ, and a few tail-vertebræ, the pelvis and both femora. The characters of the vertebræ may be sufficiently gathered from the accompanying figures.



Restoration of a vertebra of *Sphæno-saurus Sternbergii* (H. von M.), seen from the side.



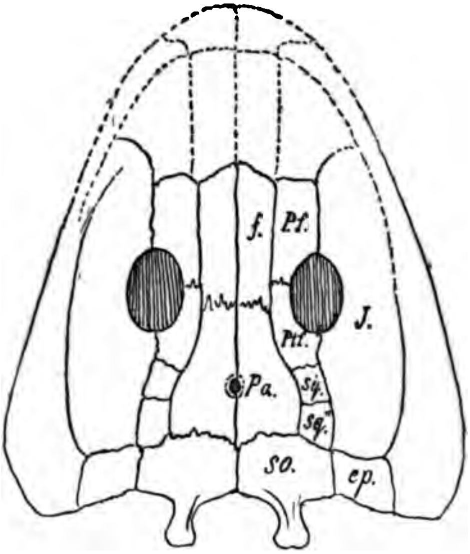
Vertebra of *Sphænosaurus Sternbergii* (H. von Meyer). Natural size, seen from below.

c. Hypocentrum arcale; *i.* Hypocentrum pleurale; *ple.* Pleurocentrum; *d.* Superior spinous process; *a.* Prezygapophysis; *p.* Postzygapophysis; *m.* Pleurapophysis.

The early ribs are six times as long as the vertebra with which they are connected; but they are shorter posteriorly, so that the 15th is only as long as the vertebra. Caudal ribs are developed and attached by a broad plate which makes the base triangular. The pelvis resembled that of *Chelydosaurus.*

Cochleosaurus Bohemicus.—This species is known from a skull, in which the anterior part is not preserved, but the length is estimated at 17 cm. and the breadth at 15 cm. The orbits are relatively small, oval, separated by twice their diameter. The parietal foramen is inconspicuous. The upper surface of the skull is covered with angular pits of varying size, which radiate over the bones on which they occur, and obscure the sutures. The jugal bones are unusually wide and large. The supra-occipital bones are prolonged backward into remarkable spoon-shaped processes, more like those which are common in the epiotic bones. A second species, *Cochleosaurus falax,* is founded on a supra-occipital bone of a small animal, in which the posterior process is expanded in a triangular form. The surface of the bone is marked with two large furrows and many small ones.

Gaudrya latistoma has a skull which is semicircular in front, with densely placed teeth in the premaxillary and maxillary bones; the vomerine bones are strongly toothed, and the palatine bones large and finely denticulated. There are seventeen teeth in the premaxillary bone on each side. They increase in size a little as they extend backward. They have a large pulp cavity and a furrowed base to the crown, as in the preceding types. A second rudimentary row is indicated by a row of five small processes. The vomer is small, and carries seven large teeth in two rows in the anterior half; and there is a transverse row of small teeth at the posterior border. The palatine bone is unusually large, and shaped as in crocodiles; it is three times as long as broad; and the inner borders are in contact throughout their length. Its anterior border is in contact with the vomer and the premaxillary bone, and its outer border is notched to form part of the palatal foramen. The lower jaw appears to have contained about seventeen teeth.



Cochleosaurus Bohemicus. One-third natural size; restored.
f. frontal. *Pt.* post frontal. *Pf.* pre-frontal. *J.* jugal. *Pa.* parietal.
so. supra-occipital. *ep.* epiotic. *sq.* squamosal.

This short notice may draw attention to the remarkable materials which Professor Fritsch has admirably described and figured, but it can convey no idea of the excellence of the collateral discussions with which he has enriched a work, that grows in merit as it progresses.

H. G. SEELEY.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

June 24, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "Supplementary Notes on the Deep Boring at Richmond,

Surrey." By Prof. John W. Judd, F.R.S., Sec.G.S., and Collett Homersham, Esq., F.G.S.

Since the author's former communication to the Society on the subject, this boring, in spite of the strenuous efforts made by the Richmond Vestry and the contractors, Messrs. Docwra and Co., has had to be abandoned, after reaching a total depth of 1447 feet from the surface. This depth is 145 feet greater than that of any other well in the London Basin, and, reckoning from Ordnance Datum, reaches a lower level by 312 feet than any other well in the district.

Before the termination of the work, temperature-observations were obtained, which, generally, confirm those previously arrived at.

The strata in which the boring terminated consisted of the red and variegated sandstones and marls previously described, which were proved to the depth of 208 feet. Although it was demonstrated that these beds have a dip of about 30°, complicated in places by much false-bedding, no conclusive evidence could be obtained concerning their geological age. They may be referred either to some part of the Poikilitic series, or to the Carboniferous (for similar strata have been found intercalated in the Carboniferous series at Gayton, near Northampton), or they may be regarded as of Old Red Sandstone age.

Some interesting additional observations have been made, since the reading of the former paper, on the Cretaceous rocks passed through in this well. Mr. W. Hill, F.G.S., of Hitchin, has found the exact analogue of the curious conglomerated chalk met with at a depth of 704 feet at Richmond. His observations entirely confirm the conclusion that we have at this depth the "Melbourne Rock" with the zone of *Belemnites plenus* in a *remanié* condition at its base. Some new facts concerning the state of preservation of the fossils in the Chalk Marl are also recorded.

With respect to the conclusions arrived at by the author concerning the distribution of the Jurassic rocks on the south side of the London Basin, an important piece of confirmatory evidence has been supplied by a deep boring made at the Dockyard-Extension Works at Chatham. This section, for the details of which the authors are indebted to the officers of the Geological Survey, shows that under the Chalk and Gault, with normal characters and thickness, there lie 41 feet of sandy strata of Neocomian age, and that these are directly underlain by blue clays of Middle Oxfordian age, as is proved by the numerous fossils which they have yielded. We have now, therefore, direct evidence of the existence and position of strata of Lower, Middle, and Upper Oolite age, respectively, beneath the Cretaceous rocks of the south-east of England.

2. "On the Igneous and Associated Rocks of the Breidden Hills in East Montgomeryshire and West Shropshire." By W. W. Watts, Esq., F.G.S.

The author, in this paper, described the succession of rocks in the small tract near the Breidden Hills situated between Welshpool and Shrewsbury. The Cambrian rocks are:—

a. Criggion Shales, dark and barren, much penetrated by intrusive diabases and about *2700 feet* thick.

b. Andesitic lavas and ashes, followed by conglomerates of the same materials.

c. Ashy grits and shales containing *Climacograptus antiquus?* *C. bicornis?* *C. Scharenbergi*, *Cryptograpsus tricornis*, *Diplograpsus foliaceus*, *Leptograpsus flaccidus?* *Beyrichia complicata*, *Trinucleus concentricus*, *Orthis testudinaria*, *Bellerophon bilobatus*. The rocks are thus of Bala age, the fossils indicating that the ashy grits and shales are on the horizon of the top of the Glenkiln or bottom of the Hartfell series.

These are followed by Silurian strata.

a. *Pentamerus*-beds. Soft sandstones and mudstones yielding *Pentamerus globosus?* *P. oblongus*, *P. undatus*, *Leptæna transversalis*, *Strophomena rhomboidalis*, *Petraia subduplicata*.

b. Purple shales, unfossiliferous.

c. Lower Wenlock Shale, with *Monograptus vomerinus?* *Cryptograpsus*, sp., *M. priodon*, var. *Flemingi*. These graduate into :—

d. Upper Wenlock Shale, with *M. priodon*, *M. vomerinus?* *M. basilicus*, *M. Nilssoni*, *M. Rœmeri*.

e. Lower Ludlow Shale. *M. colonus*, *M. Nilssoni*, *M. Salweyi*, *M. lintwardenensis*.

The paper concluded with microscopical descriptions of the igneous rocks, of which there are two sets :—

a. An older set interbedded with the Cambrian and consisting of andesites bearing a large percentage of a mineral allied to enstatite, together with augite and a small quantity of hornblende and mica. These are chiefly lavas, but some few are perhaps intrusive rocks and dykes.

b. Intrusive rocks of a diabase type, generally, however, containing a variety of enstatite identical with that in the andesites. These are intrusive in the Cambrian rocks, and from their relations appear to be most probably of Post-Silurian age.

3. "Note on the Zoological Position of the genus *Microchœrus*, Wood, and its apparent Identity with *Hyopsodus*, Leidy." By R. Lydekker, Esq., B.A., F.G.S.

In this paper the author discussed the character of the genus *Microchœrus*, Wood, from English Upper Eocene deposits, which has hitherto been regarded as an Ungulate form, and showed that it is really an Insectivore. He also indicated that the American Eocene form *Hyopsodus*, Leidy, is almost certainly identical with *Microchœrus*.

4. "Observations on some imperfectly known Madreporaria from the Cretaceous Formation of England." By R. F. Tomes, Esq., F.G.S.

This communication contained notes on several species of Cretaceous corals. The author considered that *Smilotrochus insignis* of Duncan must be referred to the genus *Ceratotrochus*, that *S. granulatus*, Duncan, was founded on immature specimens of *Trochocyathus Wiltshirei*, Duncan, that *Micrabacia Fittoni*, Duncan, is a variety of *Cyclocyathus Fittoni*, that the genus *Podoseris*, Duncan, and probably *Syzygophyllum*, Reuss, are the same as *Rhizangia*, M.-Edw. and Haime, and consequently *P. mammiliformis*, Duncan, and *P. elongata*, Duncan, are species of Rhizangia. He further states that

Turbinoseris, Duncan, is identical with *Leptophyllia*, of Reuss, and as the specific name *de Fromenteli* is preoccupied in the latter genus, he proposed to substitute the name *Leptophyllia anglica*, Tomes, for *Turbinoseris de Fromenteli*, Duncan. A new species, probably of *Smilotrochus*, from the Gault of Folkestone, and a new *Isastræa* from Atherfield, were described, and notes added on the occurrence in British localities of *Barysmilia tuberosa*, Reuss, *B. Cordieri*, M.-Edw. and Haime, *Pleurosmilia neocomiensis*, E. de From., of a small form of *Astrocœnia*, and of *Isastræa Reussiana*, M.-Edw. and Haime (=*Ulophyllia crispa*, Reuss.). The occurrence of *Beaumontia Egertoni*, derived from the Carboniferous Limestone, in the Upper Greensand of Cambridge, was reported.

5. "Correlations of the Curiosity-Shop Beds, Canterbury, New Zealand." By Capt. F. W. Hutton, F.G.S.

The "Curiosity Shop" is a locality on the River Rakaia in the Canterbury Plains, and has been thus named on account of the numerous fossils found in some calcareous sandstones cut through by the river. The section exposed consists of—1. River-gravels. 2. Loose grey quartz sands. 3. Soft calcareous sandstone with glauconite, passing downwards into tufaceous clay. 4. Calcareous sandstone without glauconite. 5. Loose grey or yellowish brown sands.

By McKay, of the Geological Survey, No. 2 had been referred to the Pareora series (Miocene ?), No. 3 to the Upper Eocene series, and Nos. 4 and 5 to the Cretaceo-Tertiary series. The author, who was inclined to class all these beds in a single series, pointed out that the only difference between the fossils found in Nos. 3 and 4, the most important fossiliferous beds, consisted in the presence of a greater number of forms in No. 3, all found in No. 4 being identical with those in the overlying bed. He then gave a complete list of the species of Vertebrata, Mollusca, Brachiopoda, Echinodermata, Bryozoa and Cœlenterata, from the locality, 48 in all, and compared them with those from the Weka-pass stone, 26 in number, and the Ototara fossils from Oamaru, to show that a large proportion were identical. He gave reasons for not agreeing with the views of Dr. Hector and Mr. McKay, who held that unconformity exists between the beds referred by them at the Curiosity Shop, in the Weka-pass district, and north of Otago, to the Upper Eocene and Cretaceo-Tertiary series respectively, and showed both from palæontological and stratigraphical data that all these rocks must be included in one system, the Oamaru system of Dr. von Haast and himself.

6. "On the Fossil Flora of Sagor in Carniola." By Constantin Baron von Ettingshausen, F.C.G.S.

The author in this paper gave the principal results of his examination of the fossil flora of Sagor, consisting of 170 genera and 387 species, of which a list was appended. The plants were obtained from 14 different localities, some of the most important species from each of which were mentioned; in one of these localities the flora underlying the brown coal of the district belonged to the uppermost Eocene, whilst the remaining stations were assigned to the lowest stage of the Miocene system. The great diversity of the fossil plants showed that the Tertiary flora of this and other localities must be considered the origin of all the living floras of the globe; for in the fossil-flora of Sagor are found plants representative of forms now found in Australia, North America and Mexico, California, Chili, India and the East Indian islands, Europe, Africa, Norfolk Island, and New Zealand. Examples of all these were cited.

CORRESPONDENCE.

A GEOLOGICAL MAP OF THE WORLD.

SIR,—The want of a tolerably detailed large-scale map of the world, coloured geologically for students and geologists generally, has often occurred to me, and I venture to direct attention to it in your columns. In the present imperfect but advancing state of our knowledge the publication of such a map, or of a geological atlas of the world, would be worse than useless; but surely one such map might well be displayed in the galleries of the Natural History Museum, or in some other similar national institution. The Jermyn Street collections being exclusively British, the Natural History Museum would seem the more appropriate place for it; and, as beautiful special diagrams of the anatomy of animals are now being prepared there, no difficulty should arise in its preparation. If made in several sheets mounted on canvas, these might be separately replaced by better ones as our knowledge increases; and the adoption of the system of colouring agreed upon by the International Congress would serve to familiarize us in England with that code of the future. We might well have far more detail than in Ami Boné's map, and, in fact, I see no reason why, where our knowledge is full, we should not have more detail than in other less known parts of the map; but orographical matter had, perhaps, better be sparingly introduced. Such a map is exhibited in the museum at Brussels, and would, I should think, add much to the educational interest of our national collection here. G. S. BOULGER.

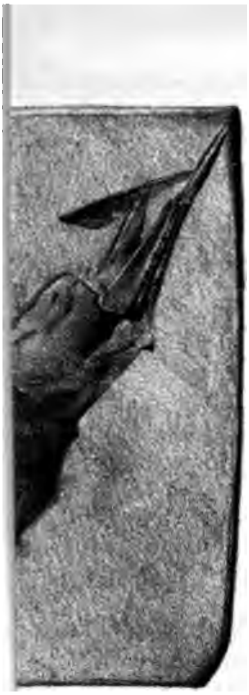
18, LADBROKE GROVE, W.

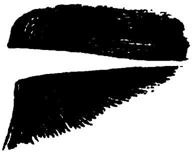
FOSSIL BIRDS.

SIR,—My friend Dr. Woodward in his interesting paper on Wingless Birds in the GEOLOGICAL MAGAZINE, Dec. III. Vol. II. No. 7, p. 308, alludes to the discovery of fossil feathers of birds in some places abroad, both in Jurassic and Tertiary strata, but he does not mention any as occurring in England. It may be interesting to the readers of the MAGAZINE to know that a small feather is recorded by Mr. J. S. Gardner, from the Tertiary Plant-beds at Bournemouth, and I have two portions of feathers from the Eocene Bembridge Limestone at Gurnet Bay, near Cowes, Isle of Wight; which has yielded to the researches of Mr. A'Court Smith so many remarkable Insect-remains, Arachnids, Crustacea and Plants, and of which I have a fine series. Remains of Birds are almost as a matter of course unusually rare in any fossiliferous rocks, and generally occur, as might be expected, in fluviatile or lacustrine deposits, and feathers seem to be still more so. Those in my collection are only fragmentary, merely the upper end of a very small feather; but perhaps Mr. Smith may have more entire examples, though I am not aware of any others having been met with in any older formations in this country. P. B. BRODIE, F.G.S.

[To the foregoing should be added the following species:
Pelagornis Barretti (Seeley). Ann. Mag. Nat. Hist. Aug. 1866.
Enaliornis Barretti. Seeley, Index to Fossil Remains, etc., 1869, Quart. Journ. Geol. Soc. Nov. 1876, pl. xxvi.-xxvii. H. W.]

Decade III. Vol II. Pl. X





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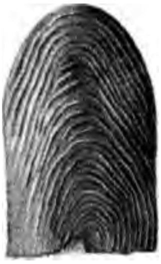

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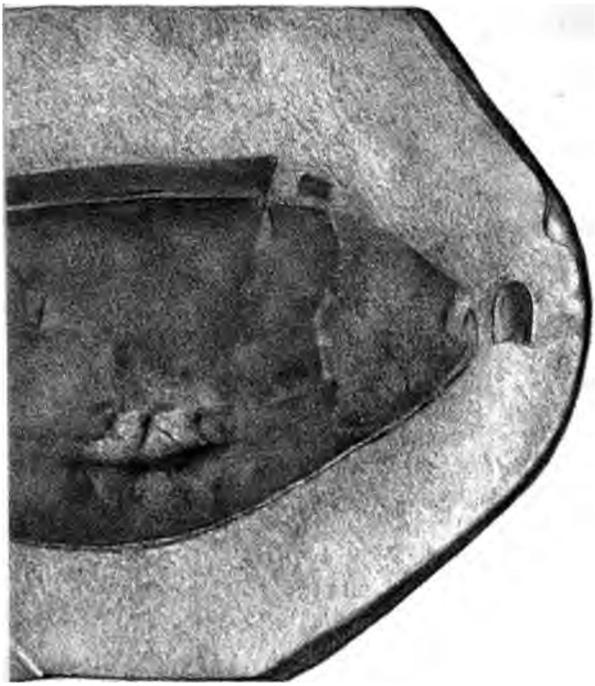

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. II.

No. IX.—SEPTEMBER, 1885.

ORIGINAL ARTICLES.

◆

I.—NOTES ON THE BRITISH SPECIES OF *CERATIOCARIS*.

By Prof. T. RUPERT JONES, F.R.S., and HENRY WOODWARD, LL.D., F.R.S.

(PLATE X.)

DR. PACKARD'S observations on the structure of the Phyllopoda, and his comparative anatomical studies of allied living and extinct genera, supply the palæontologist with sound reasoning for referring the Phyllocarida to the Nebaliad type as a centre for a great group of obscure fossil forms, and as a starting-point for the Decapoda.[1] His views have been referred to in some detail in the GEOL. MAG. for August last, pages 349–352.

Order PHYLLOCARIDA, Packard (1879).

Genus CERATIOCARIS, M'Coy (1849).

The generic characters of *Ceratiocaris* have been described by M'Coy, Salter, H. Woodward, and Barrande in their several works and memoirs referred to in the sequel. James Hall, R. P. Whitfield, A. S. Packard, J. M. Clarke, Fr. Schmidt, C. E. Beecher, O. Novák, and others have added much information, general and special, on this and allied genera. The appended synonymy of the genus supplies full references to published notices on *Ceratiocaris* and some of its kindred.

We offer the following diagnosis of *Ceratiocaris*.

Carapace bivalved, probably with membranous attachment, no distinct hinge-joint observable; valves subovate, semiovate, subquadrate, or trapezoidal; contracted in front with the end sharp or rounded above the median line of the valve; more or less truncate behind. Rostrum elliptical in shape, of a single, lanceolate piece, chevron-marked. Antennæ (?) obscure. Dentate mandibles often apparent. Body many-jointed, with fourteen or more segments, of which 4–7 extend beyond the carapace; ornamented with delicate raised lines. Some or all of these segments bore small, lamelliform, branchial appendages.[2] Last segment longest, supporting three caudal spines, namely, (1) a strong tapering telson (style), thick at the top or proximal end, with its trifid articulating surface

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[1] See "Monograph of the Phyllopod Crustacea of North America, with remarks on the Order Phyllocarida. By Dr. A. S. Packard, jun. (Extracted from the Twelfth Annual Report of the U. S. Geol. and Geograph. Survey), 1883."

[2] See the Sixth Report on Fossil Crustacea, Brit. Assoc. Report for 1872, p. 323; and GEOL. MAG. Vol. IX. p. 564; also a descriptive note by Mr. R. Etheridge, jun., in the Mem. Geol. Surv. Scotl., Explan. Sheet 23, 1873, p. 93, and Ann. Mag. Nat. Hist. ser. 4, vol. xiv. 1874, p. 9.

(resembling that in the telson of *Limulus*) pointed at the distal extremity, and more or less spinose, as shown by the bases of attachment for small lateral prickles, and (2) two shorter, simpler, lateral appendages (stylets). The surface of the valves has a lineate ornament, and the ventral margin has a thin raised rim.

Ceratiocaris, M'Coy, 1849.

1839. *Onchus*, Agassiz (in part). In Murchison's Silurian System, p. 607.

1848. *Onchus*, Phillips (in part). Mem. Geol. Surv. vol. ii. part 1, p. 226.

1849. *Pterygotus*, M'Coy. Ann. Mag. N. H. ser. 2, vol. iv. p. 394.

1849. *Ceratiocaris*, M'Coy. Ann. Mag. N. H. ser. 2, vol. iv., p. 412.

1851. *Pterygotus*, M'Coy. Brit. Palæoz. Fossils, fasc. 1, p. 175.

1851. *Leptocheles*, M'Coy. Brit. Palæoz. Fossils, fasc. 1, p. 176.

1851. *Ceratiocaris*, M'Coy. Brit. Palæoz. Fossils, fasc. 1, p. 136.

1851. *Pterygotus* (*Leptocheles*), Bronn. Lethæa Geognost. vol. i. part 1, p. 40.

1852. *Onchus*, James Hall. Geol. Surv. New York, Palæontol. vol. ii. p. 320.

1852. *Ceratiocaris*, Bronn. Leth. Geogn. vol. i. part 2, p. 539.

1853. *Dithyrocaris*, Geinitz. Verst. Grauwack. Sachsen, Heft 2, p. 23.

1853. *Leptocheles*, M'Coy. Quart. Journ. Geol. Soc. vol. ix. p. 13.

1853. *Ceratiocaris* (*Leptocheles*), Barrande. Neues Jahrb. für Min. etc. 1853, Heft 3, p. 342.

1853. *Dithyrocaris?* D. Sharpe. Quart. Journ. Geol. Soc. vol. ix. p. 158.

1854. *Ceratiocaris et Leptocheles*, Murchison. Siluria, 1st edit. p. 236.

1854. *Ceratiocaris*, Morris. Catal. Brit. Foss. 2nd edit. p. 102.

1856. *Ceratiocaris*, Salter. Quart. Journ. Geol. Soc. vol. xii. p. 33.

1859. *Ceratiocaris*, J. Hall. Geol. Surv. New York, Palæontol. vol. iii. p. 420.

1859. *Ceratiocaris*, Salter. In Murchison's Siluria, 2nd edit. (3rd including Sil. Syst.), pp. 262, 538.

1860. *Ceratiocaris*, Salter. Ann. Mag. Nat. Hist. ser. 3, vol. v. p. 158.

1863. *Ceratiocaris*, James Hall. Sixteenth Ann. Rep. of Regents, p. 72, pl. 1.

1865. *Ceratiocaris*, H. Woodward and Salter. Catal. and Chart. Foss. Crustacea.

1865. *Ceratiocaris*, H. Woodward. Geol. Mag. Vol. II. p. 401.

1865. *Ceratiocaris*, Huxley and Etheridge. Catal. Foss. Mus. Pract. Geol. p. 79.

1866. *Ceratiocaris*, H. Woodward. Geol. Mag. Vol. III. p. 203.

1866. *Ceratiocaris*, Salter. Mem. Geol. Surv. vol. iii. p. 294.

1867. *Ceratiocaris*, Salter. In Murchison's Siluria, 3rd edit. (4th including Sil. Syst.) pp. 236 and 516.

1868. *Ceratiocaris*, Bigsby. Thesaur. Silur. p. 73.

1871. *Ceratiocaris*, H. Woodward. Geol. Mag. Vol. VIII. p. 104.

1872. *Ceratiocaris*, H. Woodward. Geol. Mag. Vol. IX. p. 564; and Report Brit. Assoc. for 1872, p. 323.

1872. *Ceratiocaris*, Barrande. Syst. Sil. Bohême, vol. i. Suppl. p. 437.

1873. *Ceratiocaris*, Salter. Catal. Cambr. Sil. Foss. Woodw. Mus. p. 177.

1873. *Ceratiocaris*, R. Etheridge, jun. Mem. Geol. Surv. Scot. Exp. M. 23, p. 93.

1873. *Ceratiocaris*, Marschall. Nomenclator Zoologicus, p. 404.

1874. *Ceratiocaris*, R. Etheridge, jun. Ann. Mag. N. H. ser. 4, vol. xiv. p. 9.

1876. *Ceratiocaris*, F. Roemer. Leth. Geogn. Th. i. Leth. palæoz. Expl. pl. 19.

1877. *Ceratiocaris*, H. Woodward. Catal. Brit. Foss. Crust. p. 70.

1877. *Ceratiocaris*, Miller. Catal. Palæoz. Foss. America, p. 213.

1878. *Ceratiocaris*, Huxley and Etheridge. Catal. Foss. Mus. Pract. Geol. p. 84.

1878. *Ceratiocaris*, Bigsby. Thes. Devonico-Carbonif. pp. 26, 246 and 247.

1878. *Ceratiocaris*, Young. Proceed. R. Phys. Soc. Edinb. vol. iv. p. 168.

1880. *Ceratiocaris*, Whitfield. Amer. Journ. Sci. ser. 3, vol. xix. p. 35.

1882. *Ceratiocaris*, B. N. Peach. Trans. R. Soc. Edinb. vol. xxx. part 1, p. 73.

1883. *Ceratiocaris*, A. S. Packard, jun. Monogr. North Amer. Phyllop. Crust.; Twelfth Ann. Rep. U. S. Geol. and Geograph. Survey, p. 450.

1884. *Ceratiocaris*, C. E. Beecher. Ceratiocaridæ Upper-Devon. Measures; Second Geol. Serv. Penns. P.P.P. p. 2.

1885. *Ceratiocaris*, O. Novák. Sitzungsb. k. böhm. Gesellsch. Wissensch.

1883. *Ceratiocaris*, H. W. and T. R. J. Report Brit. Association for 1883, p. 217.

1884. *Ceratiocaris*, T. R. J. and H. W. Geol. Mag. Dec. III. Vol. I. p. 396.

1. CERATIOCARIS MURCHISONI (Agassiz), and its variety LEPTODACTYLUS (M'Coy).

Some imperfect caudal appendages or spines (telson or style, and lateral spines or stylets), from the Uppermost Ludlow strata, near Ludlow, were figured in Murchison's Silurian System, in 1839, as fish-defences. These were recognized by Prof. F. M'Coy in 1853 as being very similar to some analogous fossils, referred by him at first (in 1849) to a slender-clawed kind of *Pterygotus* from the Lower Ludlow, at Leintwardine, near Ludlow, which he separated from that genus as *Leptocheles leptodactylus.* M'Coy suggested that Murchison's fossil should be known as *L. Murchisoni.*[1]

In each case we have only caudal spines to deal with; but M'Coy's specimens (Brit. Pal. Foss. pl. 1 E, figs. 7, 7*a*, 7*b*) are much more slender than Murchison's (Sil. Syst. pl. 4, figs. 10 and 64, and Siluria, pl. 1 E, figs. 1, 2), and less strongly ribbed; and therein they seem at first sight to have specific differences.

Several good examples of more or less perfect sets of the three caudal spines corresponding in size, strength, and ribbing, with Murchison's fossils have been met with. These show evidence of lines of prickles (by the presence of little pits, representing their bases, along one or more lines); and on close examination the engravings in the Sil. Syst. and Siluria (the specimens have been lost) show some slight indications of this spinose ornament. This is not visible, however, in M'Coy's figures or specimens (Cambridge Museum, *a*/923, *a*/924). Of these latter, more delicate, caudal appendages, very few other examples occur.

In the collocation of these caudal appendages with their respective *carapaces* we have some doubt and difficulty.

We have not found a carapace directly associated with any complete spines of either the *Murchisoni* or *leptodactylus* type except in the case of a very small specimen (M. P. G. x ½), which appears to have the caudal appendages of *C. Murchisoni* and the carapace of Salter's "*leptodactylus.*" With regard to both, however, the late Mr. J. W. Salter satisfied himself that he knew their special carapaces, for he described them at p. 157 of the Ann. Mag. Nat. Hist. for March, 1860: where also he refers both species to the *Ceratiocaris* of M'Coy. Judging from his Latin diagnoses, he allocates to the former—"a cephalothorax (carapace) two inches long, oblong, convex, ornamented with interrupted, nearly-straight, wide-apart lines. The caudal appendages long, sub-cylindrical; the centre spine (telson) strong, bulbous at its base, and with a strong dorsal rib; the side spines long. All ribbed. The whole animal medium-sized. Specimens possessed by the geologists at Ludlow and by the Museum of Practical Geology." The carapace described here does not agree with any that we can associate with the caudal spines intended. Nor do we find at Ludlow exactly the kind of carapace required.

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[1] Prof. M'Coy's observations are as follows:—" . . . As before mentioned, figs. 9. 10, and 11 [Sil. Syst. pl. 4; omit figs. 9 and 11], representing the so-called *Onchus Murchisoni*, Ag., are almost identical in form, size, sculpturing, and all other characters (as far as they are represented in these drawings), with the distinctly didactyle pincers which I have figured (Brit. Pal. Foss. pl. E, fig. 7) from Leintwardine, under the name *Lept. leptodactylus*. . . . If this approximation prove correct, the fossil should in future be called *Leptocheles Murchisoni* (Ag. sp.)."—Q. J. G. S. vol. ix. 1853, p. 13.

To *C. leptodactylus* Mr. Salter apportioned "a cephalothorax long, triangular, acute in front, broad and rounded behind. Free abdominal segments 7–8 in number, subquadrate, deeply impressed at the sides. Caudal appendages long, striate; the central spine (telson) scarcely thicker than the long lateral spines. Surface of the head (carapace) smooth, or marked with only very short sparse lines. Abdominal segments strongly striate. The whole animal elongate and more than a foot long." One particular specimen in the Mus. Pract. Geol. is referred to by Mr. Salter at p. 158. We are at a loss here also in fitting the indicated (*slender*) appendages to the carapace described. We have examined this and other good specimens, labelled *C. leptodactylus* by Mr. Salter or at his direction, in which the *carapace* agrees with his description. One carapace is of large size, nearly perfect, about 125mm. (5 inches) long, by 55 mm. at greatest height, M. P. G. x $\frac{1}{6}$, Catal. Cambr. Sil. Foss. 1878, p. 142. A specimen nearly perfect, M. P. G. x $\frac{1}{7}$ (Catal. 1878, p. 142), 60 mm. long by 28 mm., gives no certain indication of the length of its telson and its two stylets, for they are crushed off short. The abdomen exposed is about 50 mm. long In specimen D of the Ludlow Museum, which has the proximal portion only of the caudal spines preserved, and in specimen B, with the appendages also broken off short, the telson was ribbed and pitted (= prickly), thereby differing from the spines known as *C. leptodactylus* (M'Coy).

There is also a well-preserved *small* specimen (M. P. G. x $\frac{1}{8}$, Catal. 1878, p. 142), with its carapace measuring only 25 mm. in length and 11 mm. in height, from the Lower Ludlow of Bow Bridge, Ludlow. This is labelled "*C. leptodactylus*," and belongs to the same species as the foregoing. Its caudal appendages are perfect, with the telson (25 mm.) about one-third of the length of the whole animal; but they differ from M'Coy's *C. leptodactylus*, for they are not only ribbed or ridged, but the telson was prickly; the laterals were probably rather more than half its length. Specimen M. P. G. D $\frac{2}{1}\frac{2}{3}$, from Dudley, however, is a thin spiniform fragment, faintly striated like *C. leptodactylus*.

Altogether the telson (style) and stylets of these specimens have a very close resemblance to those known as *C. Murchisoni* (see above, p. 387). One example, from Dudley, described and figured as such in the GEOL. MAG. Vol. III. p. 204, Pl. X. Fig. 8 (stylets and the upper moiety of the style, 90 mm., even more than 5 inches long when perfect), was doubtlessly proportionate to the large carapace, M. P. G. x $\frac{1}{6}$, above alluded to, as belonging to an animal more than 12 inches long; the carapace, exposed segments, and the telson being each a third of the whole length.

Other good specimens of these caudal appendages are:—

Ludlow Museum, C. Lower Ludlow; Leintwardine.[1] Lower portion of the style and stylets, 130 mm. (5$\frac{1}{4}$ inches).

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[1] This is mounted with specimen D as one specimen; but the discrepancy between the two parts is readily seen. It is referred to by the Rev. J. D. La Touche in his *Geology of Shropshire*, 1884, p. 77.

Owens College Museum. From near Ludlow. Style and stylets, not perfect, 105 mm.

M. P. G. $\frac{23}{36}$, Catal. 1878, p. 118. Leintwardine. Style, 103 mm. This and a piece of a carapace associated are labelled "*C. tyrannus*, Salter."

Mr. Morgan's Collection: Cwm-y-sul, near Welshpool (Wenlock Shale). Fragment of style, with stylets, 95 mm.

Ludlow Museum, P. Lower Ludlow; Trippleton, near Leintwardine. Lower part of style and stylets, 80 mm.

Specimens B, C, D, in the Oxford Museum, from the greenish-grey mudstone near Ludlow, are also good tail-pieces.

Broken pieces:—

Murchison's fig. 10, pl. 4, Sil. Syst. (fig. 1, pl. 19, Siluria), Upper Ludlow beds. One piece measures 92 mm., and more, if the piece lying at its end belonged to it.

Fig. 9, Pl. X. GEOL. MAG. Vol. III. (M. P. G. $\frac{17}{16}$, Catal. p. 84), Casterton, Low Fell, Kirkby-Lonsdale; Wenlock Shale. Fragments, 50 mm.

Cambridge Museum, *b*/7. Upper Ludlow beds; Benson Knot, Kendal. Fragment, 43 mm.

M. P. G. x $\frac{1}{26}$, Catal. p. 142. Upper Ludlow; Benson Knot, Kendal. Fragments, 40 mm.

Cambridge Museum (Marr Coll.). Upper Coldwell beds=Wenlock; south of Coldwell quarry, Windermere. Part of style and ends of stylets, 40 mm.

Small fragments, smooth (? *Murchisoni*); straight and ribbed; curved and ribbed (? *Murchisoni*); M. P. G. x $\frac{1}{30}$, $\frac{1}{31}$, $\frac{1}{32}$; from the Downton Sandstone; Kington, Herefordshire.

Strongly ribbed and pitted (=spinose), British Museum; Bury Ditch, Salop; and Oxford Mus. D, Ludlow.

Both in M'Coy's *C. leptodactylus* and *C. Murchisoni* (the latter =Salter's *C. leptodactylus*, in part, and his MS. *C. tyrannus* and *C. gigas*) the last abdominal segment is striated with straight, somewhat inosculating, raised lines; and other segments, where preserved, are similarly marked. A somewhat crushed specimen from Danefield, Kington, Herefordshire (Lower Ludlow), M. P. G. x $\frac{1}{2}$, Catal. p. 141, showing a terminal segment with similar nearly straight, but wriggly, inosculating, thin riblets, and ridged and fluted caudal appendages, as far as preserved, has been labelled *C. gigas* by Salter; but this may well belong to the series here placed as *C. Murchisoni*; *C. leptodactylus* being restricted to M'Coy's specimens and figs. 7, 7*a*, 7*b*, and a few other slender and simply striate forms. The carapace belonging to these is not yet known. It is quite possible that these rare and thinner styles and stylets may have belonged to some variety of *C. Murchisoni*. In this case a separate specific name is not required for them, and they should be merged in *C. Murchisoni*, as arranged in H. Woodward's Catal. Brit. Foss. Crust. 1877, p. 71.

There is little or no doubt that the figure given by Mr. Salter in the Catal. Cambr. Silur. Fossils, 1873, pp. 16, 164, and 178, as illustrative of the genus, is *C. Murchisoni* as here defined. The *eye-spot*, however, and the *hinge-joints* are, in our opinion, superfluous and not substantiated.

The synonyms of CERATIOCARIS MURCHISONI (Agassiz), 1839 :—

1839. *Onchus Murchisoni*, Agassiz, in Silur. Syst. p. 607, pl. 4, fig. 10 (not figs. 9 and 11); and *Onchus*, fig. 63?, and Ichthyodorulites, fig. 64.
1851. *Leptocheles* (*Murchisoni*), M'Coy. Synops. Brit. Palæoz. Foss. fasc. 1, p. 176.
1853. *Leptocheles Murchisoni* (Agass.), M'Coy. Quart. Journ. Geol. Soc. vol. ix. p. 13 (omitting allusion to figs. 9 and 11, Sil. Syst.).
1854. *Leptocheles Murchisoni* (M'Coy), Murchison. Siluria, 1st ed. p. 236, pl. 19, figs. 1, 2, and *sp.* fig. 3.
1859. *Leptocheles Murchisoni* (M'Coy), Murchison Siluria, 2nd ed. (3rd including Sil. Syst.), pp. 263, 538, pl. 19, fig. 1 (2 and 3?).
1860. *Ceratiocaris Murchisoni* (M'Coy), Salter. Ann. Mag. Nat. Hist. ser. 3, vol. v. p. 157.
1866. *Ceratiocaris Murchisoni*, H. Woodward. GEOL. MAG. Vol. III. p. 205, Pl. IX. Figs. 8 and 9.
1867. *Leptocheles Murchisoni* (M'Coy). Salter, in Siluria, 3rd ed. (4th including Sil. Syst.), p. 134, pl. 19, figs. 1 and 2.
1867. *Leptocheles* (*Ceratiocaris*) *Murchisoni* (M'Coy). Salter, in Siluria, 3rd (4th) ed. p. 237, pl. 19, figs. 1 (2, 3?).
1867. *Ceratiocaris Murchisoni* (Agass.). Salter, in Siluria, 3rd (4th) ed. p. 516, pl. 19, figs. 1 and 2.
1867. *Ceratiocaris Murchisoni* (M'Coy), H. Woodw. Cat. Brit. Foss. Crust. p. 71.
1884. *Ceratiocaris Pardoensis*, La Touche. Geol. Shropshire, p. 77, pl. 17, fig. 563.
1884. *Ceratiocaris leptodactylus*, La Touche. Geology of Shropshire, p. 77, pl. 17, fig. 566 (young *C. Murchisoni*).

The synonyms of CERATIOCARIS LEPTODACTYLUS, M'Coy, founded on certain slender tail-spines, which may have belonged to a varietal form of *C. Murchisoni* (Agassiz):—

1849. *Pterygotus leptodactylus*, M'Coy. Ann. Mag. Nat. Hist. ser. 2, vol. iv. p. 394.
1851. *Pterygotus leptodactylus*, M'Coy. Synops. Brit. Palæoz. Foss. fasc. i. p. 176, pl. 1 E, figs. 7, 7*a*, 7*b* (not figs. 7*c*, 7*d*).
1853. *Leptocheles leptodactylus*, M'Coy. Quart. Journ. Geol. Soc. vol. ix. p. 13.
1859. *Leptocheles leptodactylus* (M'Coy), Murch. Siluria, 2nd (3rd) ed. pp. 263, 538.
1860. *Ceratiocaris leptodactylus* (M'Coy), Salt. Ann. Mag. Nat. Hist. ser. 3, vol. v. p. 157.
1867. *Leptocheles* (*Ceratiocaris*) *leptodactylus* (M'Coy). Salter, in Siluria, 4th ed. (including Sil. Syst.), p. 237.
1867. *Ceratiocaris leptodactylus* (M'Coy). Salter, in Siluria, 4th ed. (including Sil. Syst.), p. 516.
1873. *Ceratiocaris leptodactylus*, Salter. Catal. Camb. Sil. Foss. p. 164.

Taking M. Salter's description of the carapace of *leptodactylus* and the appendages of *Murchisoni* as really both belonging to the latter, and the more slender caudal spines (*leptodactylus* of M'Coy) as belonging to a variety of the latter; we have looked for the two-inch oblong carapace which Mr. Salter thought he had found for *Murchisoni* (Ann. Mag. Nat. Hist. *l.c.*), but we have not met with it at Ludlow, as led to expect by his remarks; nor is it in the Museum of Practical Geology, to which also he refers us. Indeed, we cannot help thinking that some confusion of the specimens is hereby indicated.

The carapace of *C. Murchisoni* (as defined by us) is pyriform, or acutely subovate, deep behind, narrow in front; gently convex on the back; outlined by a bold elliptical curve on the ventral margin, which rises up to form with the dorsal edge a sharp angle in front, above the median line of the valve; but this and other features were varied by age and sex, and have been modified by pressure in the different specimens. The antero-ventral margin is sometimes indrawn, making the point in front more acute. The hinder margin is truncate with an elegant ogee curve, full below, and ending above in the postero-dorsal angle, often but not always sharply defined. In some cases the ventral margin is much deeper than in others. Some fragments of carapaces from Leintwardine (Ludl. Mus. O., and M. P. G. $\frac{x}{3}\frac{x}{8}$) are ornamented with longitudinal lines or striæ of varying strength.

Seven abdominal segments are usually exposed.

Good specimens of *C. Murchisoni* (Agass.) :—

M. P. G. x $\frac{1}{3}$.—Carapace, 125 × 55 mm., with acute prow. Smooth, longitudinal linear ornament. Long form of carapace. Leintwardine.

M. P. G. x $\frac{1}{7}$.—Carapace, 60 × 28 mm. Smooth and glazy.
Seven segments, about 50 mm. (the last one about 20 mm.). Telson crushed. Long form of carapace. Leintwardine.

Ludl. Mus. D.—Carapace, 50 × 30 mm. Smooth.
Seven segments, 55 mm. (the last one 20 mm.). Some with straight striæ.
Telson imperfect. Short form of carapace. Leintwardine?

Ludl. Mus. B.—Carapace, about 50 × 30 mm. Short form of carapace.
Exposed segments (crushed up), 50 mm. With straight, wriggly striæ.
Telson broken. Leintwardine.

M. P. G. x $\frac{1}{6}$.—Carapace, 40 × 20 mm., with acute prow. Smooth and glazy; at the place of the teeth.
Five? segments, about 30 mm. Long form of carapace. Leintwardine.

M. P. G. x $\frac{1}{8}$.—Carapace, 25 × 11 mm. Small, smooth, sharp in front, marked by teeth inside.
Seven? segments, 28 mm. (the last one 14 mm.). Linear ornament.
Telson, 25 mm. Ridged and pitted (spines). (Stylets about 12 mm. Ridged.) Long form of carapace. The whole animal 3⅛ inches in length. Bow Bridge, near Ludlow.

Ludl. Mus. A.—Carapace, 24 × 13 mm. Small, smooth, subovate, sharp in front.
Seven segments, 30 mm. (the last one 12 mm.). Longitudinally striate.
Telson imperfect (12 mm. preserved). Medium form of carapace. Leintwardine?

Oxford Mus. J, K, Q, are small specimens from the Lower Ludlow, with features closely resembling those of *C. Murchisoni.*

Addendum.

1853. *Dithyrocaris Murchisoni* (Agass.), Geinitz. Verstein. Grauwackenformation in Sachsen, u.s.w. Heft 2, p. 24, pl. 19, fig. 13.

1866. *Ceratiocaris Murchisoni,* Jones. Ann. Mag. N. H. ser. 3, vol. xviii. p. 40.

This is the distal end of tapering, costulate telson (or stylet?), and is quite comparable with *C. Murchisoni* (Agassiz), as indicated by Dr. H. B. Geinitz. It was obtained from the Silurian Grauwacké beds of the Gunzenberg, between Möschwitz and Pöhl, near Plauen, together with Graptolites, *Orthoceras*, and *Pterinea*.

2. CERATIOCARIS LUDENSIS, H. Woodward.

1871. *Ceratiocaris ludensis*, H. Woodward. GEOL. MAG. Vol. VIII. p. 104, Pl. III. Fig. 3.
1884. *Ceratiocaris ludensis*, Jones and Woodward. GEOL. MAG. Dec. III. Vol. I. p. 396.

This large and indeed gigantic *Ceratiocaris* is represented by seven abdominal segments, with the caudal appendages of telson and two stylets, in the Ludlow Museum, and has been described in the GEOL. MAG. for March, 1871, and illustrated with a reduced figure. The carapace is there estimated as having probably been eight inches in length. The segments giving eight inches, and the telson being about nine inches in length, the animal would be more than two feet in total length. As pointed out in the paper referred to, the telson is certainly the longest known. Thus we find the relative proportions to be for *C. ludensis*, H. W., 144; *C. Murchisoni* (Agass.), 128 (as defined above); *C. Deweii* (J. Hall), 100; *C. bohemica*, Barr. (Brit. Mus.), 84; *C. stygia*, Salter, 32; *C. Nœtlingi*, F. Schmidt, 26; *C. papilio*, Salter, 16.

The segments are ornamented along the back with imbricated or lattice-like, raised, lines, which pass downwards on the sides into oblique and then curved wrinkles, and sometimes form a reticulation. The ultimate segment is striated longitudinally with interrupted and inosculating lines. The spines are stout, tapering slowly, slightly curved inwards (downwards), delicately ribbed, and bear close-set marks of the bases of small spines between or on some of the ridges.

This fine specimen is imbedded in the greenish-grey, sandy, laminated mudstone of the Lower Ludlow series, at Church Hill, Leintwardine, near Ludlow, with Graptolites. It was found by the late Mr. H. Pardoe, and is preserved in the Ludlow Museum.

3. CERATIOCARIS PAPILIO, Salter. (Pl. X. Fig. 1.)

1859. *Ceratiocaris*, Salter. In Murchison's Siluria, 2nd (3rd) edit. p. 262, woodcut fig. 1, p. 538.
1860. *Ceratiocaris papilio*, Salter. Ann. Mag. Nat. ser. 3, vol. v. p. 154, woodcut fig. 1, and p. 155.
1865. *Ceratiocaris papilio*, Salter and H. Woodward. Catal. and Chart Foss. Crust. p. 17 (not fig. 5).
1865. *Ceratiocaris papilio*, H. Woodward. GEOL. MAG. Vol. II. p. 403, Pl. 11, Figs. 1 and 2.
1867. *Ceratiocaris papilio*, Salter. In Siluria, 3rd (4th) edit. p. 236, woodcut fig. 1 (not fig. 2), and p. 516.
1873. *Ceratiocaris papilio*, Salter. Catal. Camb. Sil. Foss. p. 178.
1873. ,, ,, R. Etheridge, jun. Mem. Geol. Surv. Scotl. Expl. Map 23, pp. 55, 56.
1876. *Ceratiocaris papilio*, Armstrong and others. Catal. W.-Scot. Fossils, p. 24.
1877. ,, ,, H. Woodward. Catal. Brit. Foss. Crust. p. 71.
1878. ,, ,, Huxley and Etheridge. Catal. Camb. Sil. Foss. p. 142.

Of the two species, so abundant in the Upper-Ludlow Shales of the Logan Water, near Lesmahago, in Lanarkshire, and described (unfortunately without good figures) by J. W. Salter in the Ann. and Mag. Nat. Hist. for March, 1860, we have examined many good specimens. As mentioned by Salter, one (*C. papilio*) has the carapace more oblong than the other (*C. stygia*), which is deepened by a greater or less angularity on its ventral margin. In the woodcut diagrams at p. 154 of his memoir, fig. 1 is the oblong form, and figs. 2 and 3 have the deep ventral angle (*C. stygia*), and yet they are all there termed *C. papilio*, evidently from oversight. In the Lesmahago district multitudes of the two species seem to have been imbedded in the black mud (now shales); and frequent references to these interesting deposits are made in Siluria, Memoirs of the Geological Survey of Scotland (especially Explanation of Map 23, p. 49, etc.), in other works on Scottish Geology, in geological manuals, etc., and in Dr. J. S. Hunter's papers in the Trans. Geol. Soc. Glasgow, vol. vii. pp. 56, 272, etc.

Carapace sub-oblong; straight on the back, gently curved below; like the prow of a boat in front, and truncate with an ogee curve behind. The anterior extremity is rather sharp and is rarely preserved; it slopes with a gentle curve downwards and backwards from the antero-dorsal angle to the ventral margin. The latter is somewhat convex in outline, with its greatest fullness near the middle and rather forward, but varying with every specimen, all being more or less squeezed out of their true shape. The front moiety usually keeps its shape more truly than the posterior region, of which sometimes the dorsal angle (as in Brit. Mus. 41896, 41897), and sometimes the boldly-curved ventral portion (as in Brit. Mus. 41894, 58669; Cambridge Mus. *b*/135; and M. P. G. x $\frac{1}{16}$) becomes the more prominent. The surface of the valves is delicately striate, with longitudinal lines, curving parallel with the ventral margin, and coarser on the ventral than on the dorsal region. In some specimens the lines are seen to converge at, or rather, as it were, to start from, the postero-dorsal angles. The telson (style), relatively stout, and very little longer than the laterals or stylets, was faintly ridged, and perhaps prickly or spinose. The whole adult animal was probably from four to six inches long.

Having seen but few specimens in which the caudal appendages are well preserved in their place (as in Brit. Mus. 41894), we get only few good measurements.

Mr. Salter says that only three or four of the abdominal segments were free (external to the carapace), but probably there were even five; for in one specimen (Brit. Mus. 58669) five segments of large size, now loose and reversed, were probably exposed beyond the carapace; and in another (Brit. Mus. 41895) four, with an imperfect fifth, have been shifted out. The segments, excepting the last one, appear in their squeezed condition to be half as long as high, and the last one as long as three of the others.

In Brit. Mus. 41894, the carapace is 60 mm. long by 30 mm. deep (or high), and probably once rather deeper, having suffered from pressure. The penultimate segment is 10 mm. long, and if there were four of that length (40 mm.), with the ultimate segment, the body-rings would be nearly 80 mm. The telson was 25 mm. (stylets 18 mm.). Thus, altogether, the animal was about 152 mm., or 6 inches, in length.

Brit. Mus. 58669 has a longer (narrowed) carapace, five body-rings, and *a broken telson*; altogether, 6¼ inches long, In another, but smaller, individual (Brit. Mus. 41895) the carapace, 40 × 20? mm.; segments, 40 mm., but shortened; and style, about 20 mm. (stylets, 15 mm. each), make about 100 mm., or four inches, of total length.

In ten good specimens from Lesmahago we have seen two of carapace only; and in all the others the body-portion is shifted, and in six of them it is quite reversed—that is, lying at the anterior instead of the posterior end, as described by Mr. Salter (Siluria, 1867, p. 236, etc.).

The specimen Cambridge Mus. *b*/135 has the rostrum lying at an angle across the anterior extremity.

Of *C. papilio*, good specimens from Lesmahago:—

Cambridge Mus., *b*/135. M. P. G. x $\frac{1}{16}$, x $\frac{1}{22}$.

Brit. Mus. 41894, 41895, 41896, 41897, 45161, 47989, 58669.

We have seen also some fossil carapaces from Benson Knot, Kendal (Upper Ludlow), which agree perfectly in form and proportions with *C. papilio* from Lesmahago, also in ornament, except that the postero-dorsal convergence of the striæ is not present. These are Brit. Mus. some of those marked 44342; M. P. G. x $\frac{1}{4}$ (Catal. 1878, p. 141); and Cambridge Mus. *b*/35. They range from 65 mm. long and 32 mm. high to 75 × 40 mm. Also a large imperfect specimen and some fragments in brown shale from Linburn near Muirkirk (Brit. Mus., all marked 58878.) The specimen *b*/35 is included in *C. inornata*, M'Coy, by Mr. Salter, Catal. C. S. Foss. 1873, p. 177.

Moreover, the specimen N in the Ludlow Museum has the proportions and appearance of *C. papilio*, as far as it is preserved (wanting the antero-dorsal angle), from Church Hill, Leintwardine.[1]

4. CERATIOCARIS STYGIA, Salter. (Pl. X. Fig. 2.)

1859. *Ceratiocaris*, Salter. In Murchison's Siluria, 2nd (3rd) ed. p. 262, woodcut fig. 2.
1860. *Ceratiocaris stygius*, Salter. Ann. Mag. Nat. Hist. ser. 3, vol. v. p. 154, woodcut figs. 2, 3 (fig. 1 is *C. papilio*).
1865. *Ceratiocaris papilio*, Salter and Woodward. Cat. and Chart Foss. Crust. p. 17, fig. 5.
1867. *Ceratiocaris stygius*, Salter. In Siluria, 3rd (4th) ed. p. 236, woodcut fig. 2, and p. 517.
1873. *Ceratiocaris stygius*, Salter. Cat. Camb. Sil. Foss. p. 178.
1873. ,, ,, R. Etheridge, jun. Mem. Geol. Surv. Scotl. Expl. Map 23, pp. 55, 56.
1876. *Ceratiocaris papilio*. Rœm. Leth. geogn. Th. i. Leth. palæoz. pl. 19, fig. 4.
1876. *Ceratiocaris stygius*, Armstrong and others. Cat. W. Scot. Fossils, p. 24.
1877. ,, ,, H. Woodward. Catal. Brit. Foss. Crust. p. 73.
1878. ,, ,, Huxley and Etheridge. Cat. Camb. Sil. Fossils, p. 142.

Carapace-valves trapezoidal; back straight, but curving down for a short distance to the mucronate dorsal angle of the anterior edge, which then slopes with a slight convexity at a sharp angle, down-

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[1] The very rich localities for these Silurian Phyllopods in the neighbourhood of Ludlow are enumerated and described in the Rev. J. D. La Touche's Handbook of the Geology of Shropshire, 1884, pp. 26, 27, especially Ludford Lane, Bow Bridge, Leintwardine, Church Hill, and Trippleton Farm. See also the Rev. W. S. Symonds' Record of the Rocks, 1872, p. 194, etc., for notices of Ludlow and its *environs* from a geologist's point of view.

wards and backwards, to about the middle of the ventral margin, where the valve is deepest (highest); and the other half of the ventral edge rises slowly with a straight or nearly straight oblique edge to the blunt postero-ventral corner, whence the truncate hind margin rises, with a gentle concave curve, to the sharp postero-dorsal angle. When the valves are spread open, a triangular space is left between the antero-dorsal angles. This condition and the shape are well shown in the specimen M. P. G. x $\frac{1}{15}$. The outline is often modified by pressure in other positions; but not to quite so great an extent, as the shape of *C. papilio* is altered by squeeze in some instances. The valves are delicately striate, with longitudinal lines curving parallel with the ventral edge, and crowded at the postero-dorsal angles. The body-segments, of which probably five were outside the carapace (though often the segments seem to have been pushed back within the carapace after death), are marked with delicate, raised, oblique, wrinkly lines on the sides, coming from angular imbricated lines on the back (as in *C. Scharyi*, Barrande, and *C. Deweii*, Hall). The joints are sometimes more than twice as high as long. The last one is as long as three of the others. The telson is short, and is apparently in some cases about half as long again as the stylets (as 50 is to 30); and some specimens show traces of thin costulæ, and perhaps of prickles. The whole adult animals were from 4 to 8 inches long.

Specimen M. P. G. x $\frac{1}{20}$ has the rostrum and teeth squeezed out loose near the front end. A large individual, Cambridge Mus. *b*/65, measures—

Carapace . . .		83 × 55 mm.
Four segments .	40	65 mm.
Last segment. .	25	
Telson		50 ,,
		198 mm. or nearly 8 inches.

A small specimen, M. P. G. x $\frac{1}{15}$, measures—

Carapace . . .		40 × 26 mm.
Four segments .	20	30 mm. ?
Last segment . .	? 10	
Telson		30 ,,
		About 100 mm. or nearly 4 inches.

C. stygia was rather larger than *C. papilio*; its telson was larger; the carapace was markedly distinct by its trapezoidal outline, deep ventral region, and mucronate antero-dorsal angle, which was not nearly so often lost in fossilization as the front angle of *C. papilio*. In its rostrum, teeth, superficial ornament of carapace and of body-rings, it seems to have closely resembled *C. papilio*. In ten good specimens from Lesmahago, two are simple carapaces; three have body-segments in places, and five have them shifted or reversed. In this respect *C. stygia* seems to have been rather less liable to the dissolution of the membranous attachments of the body than its associate *C. papilio*.

A postero-dorsal fragment in Cambridge Museum (Marr Coll.), from the Denbighshire series (Wenlock), at Dinasbran, Llangollen, showing fine striæ above, and coarse striæ below, and the usual convergence of striæ, belongs probably to *C. stygia.*

Good specimens of *C. stygia* from Lesmahago are Cambridge Mus. *b*/136, *b*/65 (the last is referred to as *C. papilio*, evidently by mistake, in Cat. C. Sil. Foss. p. 178); M. P. G. x $\frac{1}{13}$ and $\frac{1}{14}$, x $\frac{1}{18}$, x $\frac{1}{19}$, x $\frac{1}{20}$, x $\frac{1}{21}$; and B. M. 41898, 45154, 45155, 45156.

In the Mem. Geol. Scotl. Expl. Map 23, 1873, at p. 49, Mr. R. Etheridge, jun., enumerates the places near Lesmahago and Muirkirk, in Lanarkshire, where *Ceratiocarides* have been found by the Surveyors, namely—

Ceratiocaris papilio, Salter, at Dunside (Logan Water), Eaglinside Burn, Logan Water (2 m. S. of Lesmahago), and Linburn.

Ceratiocaris stygia, Salter, at Kip Burn (Logan Water), Eaglinside Burn, and Linburn.

Ceratiocaris, caudal appendages, at Long Burn (Logan Water), Dunside (Logan Water), Logan Water (6 m. S.W. of Lesmahago), Lann Burn, and Douglas Water.

Abdominal segments and appendages probably belonging to *C. stygia* are:—

B. M. 58878, Linburn, Muirkirk. A telson, not quite perfect at base, 35 mm. long, associated with some obliquely-striate segments.

B. M. 41899, Lesmahago. Four segments, 27 mm., and M. P. G. x $\frac{1}{35}$*c*, four segments, 30 mm., and in each case two short ensiform stylets attached (style wanting).

B. M. 41900 and 41901, Lesmahago. Three abdominal segments, obliquely striate, and an ultimate segment with both oblique and straight striæ, probably due to two layers of the test. Telson, 30 mm. long; and two ensiform stylets, each about 13 mm. long.

M. P. G. x $\frac{1}{15}$, $\frac{1}{25}$*a*, $\frac{1}{25}$*b*, $\frac{1}{25}$*d*, Logan Water, Lesmahago. Segments with oblique striæ (one ultimate segment has straight striæ), not well preserved.

Oxford Mus. E. Seven segments and two spines, imperfect. Leintwardine.

One of the specimens in the Brit. Mus. marked 59648, from Lesmahago, is a small acute-ovate carapace (25 × 15 mm.), to which is attached a complete, but somewhate crushed body of 13–14 segments, 6–7 (15 mm.) of which are external, and have appended two caudal spines, of which the longest may be the telson (12 mm. long), and the other, nearly as long, one of the stylets.

At first sight this looks like the small *C. Murchisoni*, Ludl. Mus. A., but it differs considerably in details. If it be not a distinct species, it may be the young of *C. stygia.*

On another of the specimens, B.M. 59648, from Lesmahago, are three loose small *bodies*, without carapaces. The largest has 13 or 14 segments, 45 mm., some of which are obliquely striate. The last five measure 25 mm., and the last one 10 mm., equal to three of the others. The telson is 20 mm. long. Another such specimen, smaller and narrower, 35 mm. long, has 14 (?) segments; the last one 7 mm. long; appendages imperfect.

These may be the loosened and shifted abdomens of young individuals of *C. stygia* or *C. papilio*, both common at Lesmahago. They cannot be mistaken for the Carboniferous *Acanthocaris*, Peach, or the Devonian *Campecaris*, Page.

EXPLANATION OF PLATE X.

FIG. 1. *Ceratiocaris papilio*, Salter. Entire specimen from the Upper Ludlow Shales, Logan Water, Lesmahago, Lanarkshire. The abdominal segments are displaced and reversed (as is very frequently the case in specimens from Logan Water) and protrude from the rostral end of the carapace. Part of the carapace of another specimen is seen near the posterior border.

,, 2*a*. *Ceratiocaris stygia*, Salter, from the same locality and formation.

,, 2*b*. Portion of the carapace, near the postero-dorsal line, showing the delicate raised wavy lines with which the entire surface is covered (enlarged three times).

,, 2*c*. The rostrum of same enlarged four times, to show the concentric striæ covering the surface.

Figs. 1 and 2*a* drawn of the natural size from specimens in the British Museum, (Natural History).

(*To be continued.*)

II.—CAN UNDERGROUND HEAT BE UTILIZED?

By J. STARKIE GARDNER, F.G.S.

GEOLOGY has long been the handmaid of Engineering. Instances are numerous in which the practical bearing of facts discovered by the devotee of the one have been recognized and utilized by the other. On the other hand, engineering enterprise has often put geologists in possession of facts of the greatest value as bases for fresh inductions. The subject now brought forward may perhaps sooner, or in a remote future, furnish another instance in which knowledge gained by the geologist may become available for a great economic purpose.

The subject of "Underground Heat" is one about which very little is known even by the specialist. There is much divergence of opinion as to the form and conditions under which this heat exists, and still more as to the depth at which it occurs. Whether the interior of the earth is solid or fluid, hot or cold, is still a debated subject; though all leading geologists are at all events agreed that it is hot, and many believe that it is partially fluid, the fluid being situated beneath the solid crust, and resting upon a solid interior. The question we have to consider is whether zones of considerable heat are likely to be within a depth at which it might be practicable to reach them.

The paramount importance of the subject, and its pressing nature, will come to be recognized when the scarcity of coal in this country shall render it impossible for us to pay for the vast supplies of food we are compelled to import from abroad either by it or by articles produced by its aid. Our statesmen and others whom it may concern will then perhaps awake to the necessity of promoting experimental research, and of obtaining new scientific knowledge; but let us hope not too late to arrest a serious diminution of our national wealth.

Coal began to be used as fuel in some localities about the 13th century; but until the beginning of the 17th, prejudice and other causes prevented its coming into anything like general use. We may form an idea of the consumption from the fact that in 1615 the number of vessels employed in the coal trade consisted of only 400 sail. Twenty-five years later between 600 and 700 were employed. The inroads on the stock of coal could not be serious until deep mining began, and it is apparent that little more than two centuries have brought us within a measurable distance of its exhaustion. The bases upon which the Royal Commission of 1871 reported the probability that the supply would not last more than 106 years are but too well known. Our working coal-fields contained but 90,207,000,000 tons available, and it was estimated that unworked fields might contain 56,273,000,000 more. Nothing has since come to light affording any ground to hope that these totals have been under-estimated; but, on the contrary, subsequent research has rendered it probable that they are too high. A century seems a long time, but it might actually be almost spanned in a single life, and certainly within the lives of the offspring of already wedded couples. The time might be prolonged by checking the unremunerative and increasing export, but any measures that could be taken would necessarily prove futile in the long run. We need not do without coal for a long time to come after our own stock is exhausted, if we have money to purchase; for we possess in Australia coal-fields 400,000 miles in extent, and in India 30,000, while China is as rich as Australia, and the United States exceed all other countries with the immense area of 500,000 miles of coal-field. The consequences of having to import our coal are however no pleasant subjects for contemplation to an Englishman.

But even the coal areas of the whole earth will be found to be finite quantities. Should the human race continue to multiply at its present rate, their exhaustion is a matter of time, and sooner or later the question that has become momentous to us will in turn become no less so to other nations. Artificial light and heat have become so essential to us, that the continued progress of humanity, if not its existence, is dependent on their supply. We need not stop to consider now the probable future of the electric light, for the question of heat would remain, and we know of no fuel at present, regularly replenished by nature, except wood and turf. By husbanding these, a residuum of civilized humanity could exist in temperate regions, but any one who has realized how marvellously the wants of the humblest creatures are provided for will be slow to believe it to be within the scope of a scheme which appears so transcendentally perfect, that the supply of one of the most vital necessaries should fail us. Coal is the limited accumulation of vegetable matter of almost a single geological epoch, a transitory store to be used we may hope during a transitory condition of things. There is no ground to suppose that the end of our planet is near, nor the cessation of life upon it within a measurable distance; and if humanity has any destiny, we must have faith that some means of satisfying its needs will be provided. We have the sun's heat above, unequally distributed and intermittent; can we ever hope with the Laputans to "bottle sunbeams"? We have the central heat beneath us ever present; can we get access to it, and will it prove more tractable? These will develope into the burning questions of the future.

We are aware of the presence of this central heat in various ways, the most direct of which is the observed increase in the temperature when the crust is bored into. A great deal of evidence upon this has been collected by the committee appointed by the British Association to investigate underground temperatures, and the result of their work was to ascertain that the increase varies from 1° F. for from every 130 to every 34 feet. Several still newer observations give a result near the latter figure. The mean is about 1° in 64 feet, the rate greatly depending on the conductivity of the matrix bored. It would perhaps be safer to take a rather higher average, as it seems likely that borings, whether filled with air or water, must as a general rule give a rather lower temperature than the rock itself. It also seems probable that the rate may increase in a compound ratio at depths beyond those hitherto reached, since radiation would be less. The observed increase would give us boiling water at 10,000 feet, and molten rock of the temperature of lava as it issues from Vesuvius, 2000° F., at a depth of 20 miles. This is only calculated, however, from what we know to take place within the first three-quarters of a mile from the surface, the greatest depth yet tested, and we shall see in the sequel that there are other reasons for anticipating that these temperatures will be met with nearer the surface.

There are, as is well known, whole classes of rocks called metamorphic, that is to say, rocks originally sedimentary, which have become crystalline through heat. They comprehend the gneisses, schists, slates, and nearly all crystalline rocks indeed which are not igneous or intrusive. There is even reason to suppose that granite itself is a clastic rock which has been fused at a great depth from the surface. They have been proved to be merely sedimentary rocks, originally formed as ordinary sea or other mud, by tracing the same strata from their crystalline to their normal and often fossiliferous condition. In the latter case we can be quite sure of their age, and are able to estimate the greatest possible depth at which they are ever likely to have been buried, by the simple process of adding together the maxima of thickness of all the more recent known sedimentary strata. Some have been metamorphosed by direct contact with igneous rocks, but the greatest work has been effected through heat generated by squeezing and pressure during the elevation of mountain chains. These are plicated rocks, but all metamorphic rocks are not plicated, and since the microscopic investigations to which they have been subjected leave no doubt as to heat having caused the alteration, we may suppose in such cases that at the depth under which they were buried the temperature must have been sufficient to cause metamorphosis. In basing any theory upon them, however, we must proceed with extreme caution, for we must first be quite sure that the heat was not the result of squeezing and movement; and, secondly, we cannot be sure of the depth of sediment which existed above them, though we have fair grounds for believing that even the Silurian system has not been buried under more than 25,000 feet of newer strata.

A more striking manifestation of the existence of heat beneath us is seen in volcanic eruptions. We learn by them that rocks are not only incandescent, but rendered molten and fluid by the intensity of the heat. It is now recognized that the explosions, showers of stones and ash, and escape of volumes of steam, which accompany eruptions and render them so terrible, are caused by the sudden conversion of underground waters in more or less superficial strata into steam. The great absorption of water that takes place in volcanic regions has often been remarked, and so soon as the heated lava is set in motion and commences to rise, it is certain that it must come into contact with saturated strata and underground waters, with the inevitable result that most violent explosions must occur. The longer the interval between two eruptions, the more deeply and completely the rocks to be rent will be saturated, and the more energetic the explosion; and eruptions are accordingly observed to be violent in proportion to the period of quiescence which preceded them. The explosions and steam are the mere accidental accompaniments of an eruption, which is fundamentally the squeezing out or escape through a vent or crack of some of the molten interior, owing presumably to an increase of pressure elsewhere. After the paroxysmal stage, that is, when the water in contact has all been blown into steam, the lava flows tranquilly enough, and may continue to well out for very long periods. It seems probable that eruptions through craters are very minor matters, and that the grand eruptions are through fissures which may extend for hundreds or even thousands of miles in almost parallel lines. The Eocene basalts of Ireland and Scotland are generally agreed by geologists to have formed part of an extensive tract that once stretched uninterruptedly through the Faroës to Iceland and Greenland. These lavas are in horizontal sheets, and there is no trace of any craters through which they could have welled, but the fissures are plain and marked by large dykes. Their outpouring seems to have been unaccompanied by explosions, for nowhere have I discovered any great deposits of scoriæ or lapilli interstratified with them, and contemporary deposits that have formed in their vicinity show no layers of ash. The Chalk also is quite or almost free from volcanic dust, while the corresponding ocean ooze of the present day invariably contains a large percentage of such extraneous matters. The results of other large and equally tranquil eruptions are to be seen in the Deccan, where there is an area under lava 200,000 square miles in extent and 6000 feet in thickness, and in Oregon an undulating plain of basalt equalling the combined areas of France and England. These facts are merely mentioned to show that volcanic eruptions are not merely local phenomena, caused by lateral thrusts or pressure, but are vents through which the heated and molten rocks of the interior overflow the surface. When we see rocks rise and burst through the crust in every part of the earth at temperatures of 2000° F., we can hardly refuse to believe in underground heat.

t directly concerns our present inquiry, however, is whether heat is at a depth which would make it impossible with our ınt appliances to reach it, or whether there is ground to hope it may some day be reached, Earthquakes are perhaps more y to yield information on this point, and as they can only, for most part, be the incompleted efforts of the molten matter to its way to the surface and find a vent, the two subjects may eated as one. Their direct connexion with eruptions is more-sometimes apparent, though not always, nor even very frequently, arthquakes are felt where there are no signs of any volcanic ity having been manifested in recent times. In Japan, where have been particularly studied, no connexion can be traced, but taly, on the contrary, the connexion is apparent. Earthquakes certainly due to movements of the earth's crust, and as these primarily of two kinds, either of elevation or subsidence, the ltants are very different in kind and degree. Those due to subnce would probably be the more local, while those due to efforts e molten interior to break through would be propagated to great nces. It would be impossible to attempt to enter into the sics of earthquakes; but I would merely say that the phenomena me are so wide-spread, and so independent of changes in the re of the superficial crust, that they appear as if they could only been propagated through the fluid or viscous substratum. The llest depth at which I have seen the focus of an earthquake ulated is four miles; this was in the vicinity of a volcanic region, uvius. Others have been determined at seven and ten miles.

peculiarity observed about earthquakes is that they are far e prevalent in winter than in summer, and that they take place e frequently when the barometer is low.[1] This effect must have a e, and the only one apparent is that the diminished pressure of the osphere admits of a corresponding expansion of the fluid interior. tension must obviously have been already extreme, for so small duction of the pressure to produce disturbances at a depth within earth's crust that may be sensibly felt at the surface. But what dea this gives of the flexibility of the crust, and how thin it must be e acted on by so slight a cause! Besides their connexion with anoes, the direct connexion of earthquakes with underground heat pparent in many ways. One of the most curious examples of this the sudden and permanent increase in temperature of the waters he Bagnères de Luchon from 46° to 122° F., following the great hquake of Lisbon. Another proof that some classes at least of earthkes are propagated through the fluid substratum lies in the fact t mountain chains often, as in Japan, prove a complete barrier to ir progress, for the Rev. Osmond Fisher has shown, in his admir- work on the Physics of the Earth's Crust, the high probability t mountain chains interrupt to a certain degree the continuity of fluid layer. Other instances of the influence of earthquakes on rmal springs must no doubt have been observed, but I have not come across them. Very valuable information as to the depths at which high temperatures are seated could be gathered in non-volcanic regions where there are hot springs by observing the outcrop of the underlying impervious stratum and estimating the depth at which it would be situated where the springs issue forth. Thus the rainfall on the Mendips may probably feed the thermal springs at 120° F. at Bath, and the depth from which the water rises would not be more than the thickness of the strata forming the basin—about 4200 feet. Again, the fact that springs of scalding water are met with in some mines of 2000 feet in depth, as at Redruth and the Comstock, makes it unlikely that the horizon of boiling water is anything like so low as the 10,000 feet estimated from the observed increment in artesian wells. We can hardly in fact conceive that the hot springs so prevalent in Germany and other parts of Europe, away from both volcanic districts and earthquake zones, rise from such prodigious depths; though they may of course do so. In volcanic districts at least, there can however be no question as to the proximity of underground heat to the surface, for its presence is apparent in fumaroles, geysers, mud caldrons, etc., not always close to vents, but often in plains at some little distance.

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[1] ee J. Rofe, C.E., F.G.S., "On Colliery Explosions," etc., Geol. Mag. 1867. IV. p. 106.

But the great proof of the thinness of the earth's crust is to be sought in the movements which are constantly taking place at its surface. Its extreme sensitiveness has only become apparent since the microphone has enabled earth-tremors to be appreciated, and we now know that the solid ground is sensitive to a footstep and vibrates under a hail-stone. The sea is the fixed, and *terra firma* the unstable element. Every accumulation of weight brought from elsewhere by any transporting agency causes the land to sink in a corresponding degree. The whole story of the sedimentary rocks is one continued record of subsidence keeping pace with sedimentation. Every layer of the Coal-measures was formed at or very near the sea-level, while the crust was giving way inch by inch under the continued additions of weight, until in South Wales it finally sagged no less than 10,000 feet. The entire Cambrian series appears to have been formed in uniformly shallow water, and yet in our area it forms a mass estimated at 23,000 feet in vertical thickness, or sufficient to have filled in solid the abyssal depths of the Atlantic. Every river delta that has been pierced shows an endless succession of estuarine beds, often hundreds of feet in thickness, but each of which is recognized by its contents to have been formed at the water's level. No sea-coast-line is at rest. Where cliffs are being eroded and carried away by the waves, there is upheaval: for it will be noticed that, irrespective of the general strike inland, the strata of which they are composed almost invariably dip away from the sea on the shore-line. This general dip can be traced all round even deep and land-locked bays, and is explicable on no other hypothesis. Where sediment is accumulating out at sea, great subsidence must take place; for were it otherwise, coasts would be surrounded with vast shoals but a few feet below the influence of the surf, and extending as far as ever the land had stretched before the sea began to act upon it. Islands *separated* off by sea-action generally exhibit a strike for the strata composing their cliffs, corresponding to that of the main-land from which they have been severed, but at a much lower level, a result that could only be brought about through subsidence or elevation. To bring forward the overwhelming proofs of this double movement on coast-lines would carry us beyond the limits of this article. During the Glacial period the land was everywhere depressed by the weight of ice, to the extent of 1350 feet in Wales; and everywhere rose when the weight was removed by the ice melting off again. In like manner I have twice observed in Iceland that lava debouching on to plains has caused them to sink bodily. Darwin's well-known explanation of the formation of coral reefs and atolls requires that subsidence should keep pace exactly with the added weight, by the depression of the rocks or banks on which they are forming.

It would be physically impossible for such movements to take place if the earth were solid throughout. The fluid or viscous layer which is near to the surface in volcanic regions must extend underneath all areas where movements of upheaval or subsidence have been observed, and since movements to a greater or less extent seem universal, the only inference is that the crust rests everywhere upon a viscous substratum. Yet we know that the earth as a whole is a rigid body, of the rigidity of steel or glass, and it is believed that its principal mass is kept solid at a temperature beyond the fusing point of rock through the pressure of the external envelope. But if this is so, the pressure must become relaxed as the surface is neared, and at a certain point the rock must obey its impulse and melt, and we must thus find at some depth or other beneath the crust, rendered solid by loss of heat, a layer in a state of fusion. The Rev. Osmond Fisher has shown the high probability that this state of things does actually exist, and many geologists are now embracing the same views. At the same time the plications the crust has undergone in many places, as at Bergen, demonstrate that it is far more flexible than had been supposed. The ceaseless removal of material, by disintegration and abrasion, from one area of a flexible crust, and its redeposition by various transporting agencies, on another, would be likely to destroy the equilibrium of the liquid layer beneath, and to cause those changes from sea to land revealed in stratified rocks, as well as the slow movements which are even now discernible on every coast. Subsidence under newly transported weight must lead to a compensating elevation elsewhere, and thus, as old lands sink, new ones rise to take their place. This appears a reasonable explanation of the movements that have taken place throughout geological time, and I know of no other that can compete with it. Pushed to its extreme we should find that all oceans are areas of sedimentation, and therefore of depression, while high lands would be areas of denudation, and therefore of elevation. Further we should expect to find that the viscous layer would seek relief at the nearest point free from sedimentation, and we should thus find our mountain chains running parallel with ancient or modern coast-lines. At first sight this would favour the theory of the permanence of ocean-basins and of continents; but the sea-bottom is itself traversed by currents which denude its surface, and lead to the formation of submarine areas of elevation which assume the form of ridges and banks and finally dry land. The movements must be infinitely complicated, but the greatest depths or hollows of the ocean would be the least likely to come under the influence of denudation, and would thus probably prove permanent. As the great ocean currents are caused by the difference in specific gravity of the tropical and polar waters, they must flow north and south, and areas relatively free from sediment would lie in the same directions, as we in fact know that the chief land surfaces do. This theory agrees with most known physical facts, and it would be interesting to trace it further did space permit.

It has been objected that a solid crust could not be supported on a liquid, but would break up and sink through. Lava, however, in cooling, forms a crust, which is supported on the still molten mass, and the crust of the earth must be, as a whole, of lighter specific gravity than the fluid it rests on.

The movements of the earth's crust are, on the whole, more compatible with a crust of 10 miles in thickness, the minimum assigned to it by physicists, than with the maximum estimate of 50 miles.

Modern engineering would not, perhaps, consider the task of piercing even such a depth as 10,000 feet, at which depth boiling water must be reached, an altogether hopeless one, were the stake sufficiently great; for mere artesian wells have been bored to the depth of nearly a mile. London would perhaps be a very unfavourable area in which to experiment, as the upper water-bearing strata are of great thickness, and have outcrops in adjacent counties. Were there any water-bearing strata however among the deep-seated Palæozoic rocks, supplies of boiling water might be confidently reckoned upon. The west of England would be a much more favourable field, but the chances are that the neighbourhood of London would be preferred, as there is still the strongest probability that coal may yet be pierced at a workable depth, and the enormous sum of £5,000,000 per annum paid by Londoners for its carriage be thereby saved.

It is hardly probable that danger would ensue from sinking a shaft even into molten lava, were it possible to do so, and I should not apprehend that any uncontrollable eruptions would ensue. Molten lava habitually fills some craters for long periods at a time, and remains in a constant state of ebullition. There is no need, however, to essay so gigantic an enterprise just yet, as a supply of more moderate heat would go far to check the rapid consumption of fuel. As illustrating the possibility of obtaining such, the following extracts[1] are of interest:

"Near St. Etienne (France) a new geyser has been discovered. At a depth of 1500 metres a vein of hot water was tapped, and the result is an intermittent fountain which sends its water to a height of 26 metres. The geyser ejects carbonic acid as well as hot water."

"The deepest artesian well in the world is being bored at Pesth, and has reached already a depth of 951 metres. The well at Paris, which measures 547 metres, has hitherto been the first. The work is undertaken by the brothers Zsigmondy, partially at the expense of the city, which has granted £40,000 for the purpose, with the intention of obtaining an unlimited supply of warm water for the municipal establishments and public baths. A temperature of 161° F. is shown by the water at present issuing from the well, and the work will be prosecuted until water of 178° is obtained. About 175,000 gallons of warm water stream out daily, rising to a height of 35 feet. This amount will not only supply all the wants of the city, but convert the surrounding region into a tropical garden. Since last June the boring has penetrated through 200 feet of dolomite. The preceding strata have supplied a number of interesting facts to the geologist, which have been recorded from time to time in the Hungarian Academy of Sciences. Among some of the ingenious engineering devices invented during the course of the boring are especially noteworthy the arrangements for driving in nails at the enormous depth mentioned above, for pulling them out (with magnets), for cutting off and pulling up broken tubes, and, above all, a valuable mechanical apparatus by means of which the water rising from the well is used as a motive power, driving the drills at a rate of speed double that previously imparted from the mouth of the well."

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[1] From "Nature" of various dates.

Whether, having obtained a supply of heat, it would be practicable to lay it on to our houses, is a question apart, but one which seems to have been solved in America.

"A very successful experiment has been made at Lockport, New York State, in supplying heat to houses by steam supplied from a central station, in much the same way as gas is supplied. The experimental works in Lockport were commenced last year, and during the late winter about 200 houses in the city were heated from the central supply, through about three miles of piping, radiating from the boiler-house, containing two boilers 16 feet by 5 feet, and one boiler 8 feet by 8 feet. These boilers were, during the winter, fired to a pressure of 35 lb. to the inch, with a consumption of 4 tons of anthracite, costing 4½ dols. a ton; during the summer but one boiler is fired, consuming a ton and a half of anthracite in twenty-four hours, and a pressure of 25 lb. per inch maintained. The boiler pressure of 35 lb. in winter, and 25 lb. in summer, is maintained through the entire length of the three miles of piping up to the points of consumption, where there is a cut-off under the control of the consumers. The distribution of heat in the apartments is by means of radiators, consisting of 1 inch pipes 30 inches long, placed vertically either in a circle or as a double row, and connected together, top and bottom, with an outlet pipe for the condensed water, which escapes at a temperature a little below boiling, and is sufficient for all the domestic purposes of the house, or is used as accessory heating power for horticultural and other purposes. The steam has also been applied at a distance of over half a mile from the boilers for motive power, and two steam-engines of ten and fourteen horse-power are worked from the boilers at a distance of half a mile, with but a slightly increased consumption of fuel. The laid on steam is being also used for cooking purposes, for boiling, and even baking, and Mr. G. Maw, F.G.S., who describes the system, witnessed in a house three-quarters of a mile from the boilers, a bucket of cold water raised to boiling heat in three minutes by the passage of the steam through a perforated nozzle plunged in the bucket. The operations of the Heating Company have been up to the present time of an experimental character, and from the 200 houses already supplied with the heating connexion, the actual cost of the coal that would have been used for heating has been provisionally received in payment, and the amount has left a wide margin over the working expenses, though the company's operations at present cover but a small portion of the area for which they have provided plant."

In conclusion, the man of science will no more doubt that supplies of heat would be forthcoming from depths of 7000 or 8000 feet than that water will be found in Chalk, or coal in the Coal-measures. Whether London will ever be supplied with heat from this source is a question apart; but it needs no seer to pierce the not-distant future when we shall be driven to every expedient to discover modes of obtaining heat without the combustion of fuel, and the perhaps far more remote future when we shall bore shafts down to the liquid layer and conduct our smelting operations at the pit's mouth.

III.—ON THE DISTRIBUTION OF THE GRAPTOLITHIDÆ IN TIME AND SPACE.

By Dr. OTTO HERRMANN.[1]

IT was indicated even by Murchison that the Graptolites constitute admirable characteristic fossils of the Silurian formation. Subsequent investigation has established that the group Graptolithidæ is essentially confined to the oldest fossiliferous formation. A single genus, the genus *Dictyograptus*, Hopk. (*Dictyonema*, Hall), occupies a remarkably exceptional position as regards its distribution in time. Formerly, indeed, this genus was separated from the proper or true Graptolites (*Rhabdophora*, Allman), and referred with some other genera (*Dendrograptus*, Hall, *Ptilograptus*, Hopk., *Callograptus*, Hall) to the Campanularidæ; but recently W. C. Brögger[2] has very clearly shown that the genus in question differs very little from the true Graptolites, inasmuch as the most important parts of the latter, such as the sicula, and the hydrothecæ, have been detected in it. By this the Graptolithic nature of the genus in question is rendered very probable. Members of the genus *Dictyograptus*, Hopk., appear among the very oldest of known Graptolites; the genus maintains itself throughout the whole of the Silurian formation, while by its side new genera make their appearance, culminate and disappear. Even after the other Graptolites had long since disappeared from the ancient sea-fauna, this genus still lived on, for we find it occurring in the Devonian.

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[1] Dr. Herrmann has published in the "Nyt Magazin for Naturvidenskaberne," vol. xxix. Heft. 2, the greater part of a treatise, in German, on the Graptolite family Dichograptidæ, the first chapter of which bears the above title, and is here translated. This is terminated by an elaborate analytical bibliography of the literature of Graptolites. The second chapter deals with the organization and economy of the Graptolithidæ, and the third (not yet completed) contains a monographic revision of the genera and species of Dichograptidæ.

[2] "Die silurischen Etagen 2 und 3 in Kristianiagebiet und auf Eker," Christiania, *1882.*

All other Graptolites, however, are confined to the three subdivisions of the Silurian :—the Cambrian, Lower Silurian (Ordovician), and Upper Silurian (Silurian System; Silurian proper).

If we wish to obtain a clear and complete picture of the vertical distribution of the Graptolites, we find the course made plain by C. Lapworth's classical memoir, "On the Geological Distribution of the *Rhabdophora*."[1] From this invaluable work it appears that not only the families and genera, but even the individual species are confined to perfectly definite levels; that the zones characterized by particular genera or species occupy the same relative position to one another over the whole earth; and that the Graptolites are well fitted to enable us to make even a detailed subdivision of the Silurian formation.

Graptolites are known from the Upper Cambrian. G. Linnarsson has described a branched species of Graptolite[2] from the *Olenus*-shales of West Gothland; *Bryograptus Callavei*, Lapw., has been found in England in somewhat younger deposits; and in Norway Cambrian strata have furnished *Dictyograptus flabelliformis*, Eichw., and *Bryograptus Kjerulfi*, Lapw. (and other species of these two genera), in great individual abundance. The question now arises :—Which of the species of Graptolites enumerated is the most ancient? Lapworth answers this question to the effect that *D. tenellus*, Linnars., and *B. Callavei*, Lapw., with *B. Kjerulfi*, Lapw., open the series of the Graptolites. On the contrary, Brögger[3] shows that in Norway, *B. Kjerulfi*, Lapw., occurs in the upper beds of the *Dictyograptus*-shales, over *Dict. flabelliformis*, Eichw., itself, and proves that this is also the case in England with *B. Callavei*, Lapw. The zone with *Bryograptus*, Lapw., is therefore in his opinion younger, both in Norway and in England, than the zone with *Dictyograptus*, Hopk. But we must regard the Swedish *Dichograptus tenellus*, Linnars., as older than *Dictyograptus flabelliformis*, Eichw., and indeed as the oldest Graptolite which has as yet become known to us. According to Linnarsson, it is contained in the *Olenus*-shales (*Peltura*-zone) of West Gothland, which is overlain by the *Dictyograptus*-shales; according to Von Schmalensee, it occurs above the *Peltura*-zone, but in deposits which are in contact therewith. *Dictyograptus tenellus*, Linnars., belongs undoubtedly to the family Dichograptidæ, Lapw., and this family is in fact the oldest family of Graptolites.

Any one who is for the first time occupied seriously with the sequence of the Graptolites in age will be exceedingly astonished at such a result, as he does not find those forms which are the most simply constructed, the uniserial and one-sided Monograptidæ. figuring also as the oldest representatives of the group. He will wonder to see the Graptolites suddenly make their appearance in the world of organisms under complicated and very elegant forms.

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[1] Ann. Mag. Nat. Hist. ser. 5, vol. iii. pp. 245 and 449; vol. iv. pp. 333 and 423; vol. v. pp. 45, 273, and 358; and vol. vi. pp. 16 and 185.

[2] It received from Linnarsson the name of *Dichograptus tenellus*, L., but erroneously. Upon this further hereafter.

[3] *Loc. cit.* pp. 145.

The oldest Graptolite family, Dichograptidæ, Lapw., appears therefore, as we have already seen, in the uppermost division of the Cambrian, attains the maximum of its development in the lowest division of the Lower Silurian (Arenig formation), and becomes extinguished before the superior limit of the Lower Silurian is reached.

The next oldest family, Phyllograptidæ, Lapw., appears to be confined to the lowest division of the Lower Silurian (Arenig). The same is the case with the family Lasiograptidæ, Linnars., or Glossograptidæ, Lapw., with its still partly problematical forms of Lower Silurian age. The Leptograptidæ, Lapw., and Dicranograptidæ, Lapw., are also confined to the Lower Silurian. The most ancient representatives of both families make their appearance in the lowest division (Upper Arenig), and the most modern are extinguished in the uppermost division (Upper Caradoc) of the Lower Silurian.

The family Diplograptidæ, Lapw., commences with isolated species as early as the lower limit of the Lower Silurian, but is fully developed only at its upper boundary and extends up into the Upper Silurian, although it dies out completely in the first division of this (Valentian).

The vertical distribution of the family Retiolites coincides with that of the preceding family.

All these families are followed, after the most luxuriant period of this group of animals is passed, and it is already rapidly declining, by the Monograptidæ. With regard to these Lapworth has shown that, contrary to previous notions, they are strictly confined to the Upper Silurian, and that therefore, according to the present standpoint of our knowledge of the Graptolites, "the mere presence of a single species of the Monograptidæ may at once be set down as conclusive evidence of the (Upper) Silurian age of its containing beds."

This family, as already indicated, is survived only by the genus *Dictyograptus*, Hopk., which passes into the Devonian. *Dictyograptus*, Hopk., is at present still unranged in the system.[1]

Passing from these brief remarks upon the distribution of the Graptolites in time, to their distribution in space, or geographical distribution, we must mention at once that our organisms are cosmopolitan fossils. Up to the present time we have been able to ascertain their existence in the Silurian deposits of three continents, Europe, America, and Australia.

In *Sweden*, where these fossils were first observed, we have to seek the localities for Graptolites in the districts of Schonen, West and East Gothland, Dalecarlia, and Jemtland, and in Gotland. The best-known names of these may be here given in order to facilitate the immediate knowledge of the position of any given locality:—they are, in Schonen (Skåne):—Röstanga, Tosterup, Jerrestad, Fogelsång, Nyhanin, Kiviks-Esperöd, Flagabro, Komstad; in Dalecarlia (Dalarne):—Nitsjö, Stygfossen, Kallholm, Gulleråsen, Osmundsberg, Enån, Skattungbyn; in East Gothland:—the Hunneberg and Klubbudden near Motala; in West Gothland:—Kongslena; and in Gotland:—Visby, Fårön, and the district of Fröjel.

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[1] S. A. Tullberg's most recent work (Zeitschr. d. deutsch. Geol. Gesellsch. 1883, pp. 223–269) contains a system in which the Dictyograptidæ, Tullb., are placed, as a new family, at the head of all other families.

The Swedish Graptolites have been very thoroughly worked out. M. von Bromel, the first observer of these peculiar organisms, Linné, who gave them their present name, Nilsson, Hisinger, L. Törnquist, and especially G. Linnarsson and S. A. Tullberg, have contributed to this accurate knowledge of the Swedish Graptolites. S. A. Tullberg has done this above all by his work "Skånes Graptoliter, I.," in which, following the example of the English palæontologist, Lapworth, he has, with the aid of the Graptolites, endeavoured to carry out a special division of the Swedish Silurian.

In *Norway* the productive fossil localities in the vicinity of Christiania also furnished Graptolites at an early date. In the capital of the district itself, or in its immediate neighbourhood, localities occur upon the Galgenberg, in the Nordal Bruns-Strasse, and at the churchyard "Vor-Frelser," near the Botanic Garden (Töien), in which well-preserved Graptolites may easily be collected. At a somewhat greater distance from Christiania are the localities Vakkerö, Malmö, Asker and Röken; and still further off we find Krekling in the parish of Eker, and the district of Ringerike with several points, such as Slemstad, Fure, etc.

During an excursion last summer (1884) another locality was discovered in Ringerike, in which thick graptolitiferous aluminous schists (*Phyllograptus*-schists of the Silurian Etage 3, and *Dictyograptus*-schists of Etage 2), may be well studied, although the state of preservation of the fossils themselves is by no means satisfactory. This point is situated above the farmstead of Val, opposite the Vikersund railway station.

In the last few years, indeed, the number of the Norwegian graptolitiferous rocks has been repeatedly increased. In the first place, H. Reusch has detected among the fossils from the peculiar, strongly-metamorphosed mica-schists of the peninsula of Bergen, Graptolites which indicate an Upper Silurian age for the beds in question. The locality for these Graptolites, which, however, are much deformed, is near the farmstead of Vagtdal.

I have myself also discovered Graptolites, in the summer of 1883, in the bluish-grey, pyritous clay-slates, which stretch from Hovind in the district of Drontheim to the Selbo lake, and, with their reddish-brown weathered surface, are conspicuous as a thick band in the mountains. These clay-slates, like most of the sedimentary rocks of the Drontheim district, are strongly metamorphosed, and, in consequence, the Graptolites, as may be supposed, are preserved in a very unsatisfactory state. The species which I could determine (*Dicranograptus ramosus*, Hall, *Diplograptus teretiusculus*? His.) indicate for the slates a horizon corresponding to the English "Upper Llandeilo" or "*Lower Caradoc*."

The Norwegian Graptolites are still but little investigated, as the naturalists of this country have directed their chief attention rather to geological investigations. There are two old memoirs by Boeck and Scharenberg; then some species are enumerated by T. Kjerulf;[1] there is a fragmentary working-up of the Norwegian Graptolites in Brögger's great work;[2] and also a small memoir by the author.[3] The further elaboration of the Norwegian Graptolites is in the hands of G. Holm, who has already furnished some excellent memoirs upon them.[4]

Great Britain, which is so richly endowed from a geological point of view, has, in different parts, excellent localities for Graptolites, and the English palæontologists, such as Murchison, Portlock, Phillips, Sedgwick, Salter, Nicol, M'Coy, Harkness, and especially Nicholson, Hopkinson, and the first authority in this department, C. Lapworth, who have taken it upon them to investigate these localities with unwearied zeal, have accumulated an abundance of material, so that the British Graptolites must be regarded as those which have been best investigated. In the districts established by the British authors in their writings—Wales, the Lake District in the north of England, Girvan, Ireland and Scotland—a whole series of localities and systems of strata have become famous in the eyes of the Graptolitist. In *Wales* this is the case with the neighbourhood of St. Davids (Arenig and Llandeilo rocks), with the Shropshire district (Caradoc and Salopian formations), and the vicinity of Conway (Tarannon). In the Lake-District in the north of England we know the neighbourhoods of Skiddaw and Sedgwick by the Skiddaw Slates of Arenig age, the Coniston Mudstones of Skellgill (Llandovery formation), and the Coniston Flags (Salopian) which occur there. *Ireland* has to show the known localities of the Bellewston Hills and County Meath (Llandovery formation, *i.e.* Valentian), and in the first rank the County Down, with Ballygrot (Caradoc and Llandovery). *Scotland*, finally, presents the Glenkiln or Lower Moffat Shales of the neighbourhood of Moffat and the district of the Lead hills; and, further, the Hartfell Shales or Middle Moffat Beds (Upper Caradoc) and the Birkhill Shales (Llandovery) of the Moffat district, as remarkably rich in Graptolites.

In *France* Graptolites are found near Fougerolles, at Cabrières near Neffiez, near Poligné, La Ménardaie, Domfront and Mortain, Vretot, Crozon, Angers, Luchon and Caffiers.

In the *Pyrenean peninsula* Graptolites have been detected both in Portugal (in the vicinity of Oporto,—Lower Silurian) and in Spain (in the deposits of Almaden and in the Sierra Morena,—Upper Silurian).

The *Sardinian* Graptolites are Upper Silurian.

Continuing our wandering, we find the next localities for Graptolites in *Silesia*, upon which F. Römer reports; in *Carinthia* and in *Bohemia*. The Bohemian Graptolites are known to all geologists. They are derived from the environs of Prague and Beraun, and the names of places which occur most frequently in our literature are: Motol, Gross-Kuchel, Königshof, Libornischl, Konieprus, Borek, Jarow, etc.

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[1] "Veiviser ved Geolog. excursioner i Christiania Omegn."—Christiania, 1865.

[2] "Die silurischen Etagen 2 und 3 im Kristianiagebiet und auf Eker."—Christiania, 1882.

[3] "Vorläufige Mittheilung über eine neue Graptolithenart, etc.," in Nyt Mag. for Naturv. vol. xxvii. (1882), pp. 341-362.

[4] *In Öfv.* Kongl. Vet. Akad. Förh. 1881.

The Silurian formations of the neighbouring *Saxony* and of *Thuringia* also present a rich storehouse; in the former country the Graptolites are all of Upper Silurian age; in the latter both Upper and Lower Silurian. The names of the long-known localities are: Frankenberg, Langenstriegis, Reichenbach, Oelsnitz, Hartmannsgrün, the neighbourhood of Saalburg and Schleiz, of Ronneburg and Saalfeld. In *Bavaria*, Culmbach. Barrande's investigations on the Bohemian Graptolites,[1] as also those of H. B. Geinitz on those of Saxony,[2] are known to every one. The writings of R. Richter upon Thuringian Graptolites[3] also merit notice.

In *North Germany*, in the Harz, we once more come upon a spot with Graptolites in their original place of deposition; our fossils have been discovered here upon the south side of the Rausberg, and near Thall at the northern margin of the mountain. For the knowledge of this we are indebted to Kayer and Lossen.

On the other hand, the points are innumerable at which Graptolites have been observed in northern erratics with which the low plain of northern Europe is strewed. In these Graptolites have been found by Römer, F. Haidenhayn,[4] and K. Haupt. It is only quite lately that S. A. Tullberg[5] has again demonstrated that one of the Graptolitiferous rocks met with in North Germany agrees perfectly both in its petrographic constitution and in the organic remains contained in it with a rock found in place in Skåne. In the island of Bornholm (investigated by Forchhammer, Johnstrup, etc.), which geologically, "forms a direct continuation of southern Sweden," various Graptolite-zones of Skåne have also been recognized.

It must also be mentioned that these characteristic Silurian fossils have been detected in several places in the widely-extended Silurian deposits of *Russia*, as in the Baltic provinces of Esthland and Ingermannland, in Poland at Zbrza near Kielce, and in the Ural. Eichwald and Schmidt have investigated Graptolites from the Baltic provinces, and Zeuschner others from Poland.[6]

The above-mentioned localities are thrown quite into the shade, as regards the state of preservation and number of the individuals, by the *North American* ones. In the widespread Transatlantic Silurian formations, especially in Canada, Graptolitic deposits have been discovered which have become inestimable mines of wealth to the palæontologist. We mention here only the results which James Hall has given in his great work.[1]

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[1] "Graptolites de Bohême," Prague, 1850.

[2] "Die Versteinerungen der Grauwackenformation in Sachsen: I. Graptolithen," Leipzig, 1852.

[3] Zeitschr. d. deutsch. geol. Gesellsch. 1850, 1851, 1866, 1871, 1875.

[4] Zeitschr. d. deutsch. geol. Gesellsch. vol. xxi. (1869), p. 143.

[5] *Ibid.* vol. xxxv. (1883), p. 256.

[6] *Ibid.* vol. xxi. (1869), p. 569.

Among the subdivisions of the Silurian established by the American geologists, the so-called Quebec Group has especially proved to be a system of strata richly charged with well-preserved and rare specimens of Graptolites. Under the name above cited the North American "Calciferous Sandstone" and the "Chazy Limestone" have been grouped together. The most celebrated locality for this group is the frequently mentioned Point Levis, the Graptolitic treasures of which were discovered in 1854. Besides this locality, Orleans Island and St. Anne's River are to be mentioned for the same horizon. Older than the Quebec Group is the Potsdam Sandstone (St. Croix and River Valley); younger are the Utica Slates (Utica), and the Hudson's River formation (Norman's Kill, in the neighbourhood of Albany, in the State of New York). Naturalists who, besides James Hall, have written upon American Graptolites, are:—Brongniart (1828), Vanuxem, Mather (1843), Emmons (1846), Billings, Prout (1861), Logan, and Nicholson.[2]

By the incessant labours of the Geological Surveys, Graptolites have been discovered in a number of the States of the Union. Hitherto our fossils have been detected in New York, Wisconsin, Ohio, Tennessee, Iowa, and Virginia, and also to the north of Belmont, in Nevada.

The knowledge of the existence of Graptolites in deposits in *South America* is of very old date. In the Republic of Bolivia, strata which hold a position about on the boundary between the Upper and Lower Silurian, have furnished several species.

In conclusion the abundantly developed Graptolite-fauna of of *Australia* must not remain unnoticed. The strata of the environs of Victoria are the equivalents of the English Arenig and Llandeilo-Bala. Their fauna has been studied by R. Etheridge, jun.,[3] and by M'Coy.[4]

W. S. D.

IV.—On the Fossil Sirenia in the British Museum (Natural History), Cromwell Road, S.W.

By Henry Woodward, LL.D., F.R.S., F.G.S.;
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AMONG the vast additions which, during the past five years, have been made to the palæontological collections in the British Museum (Natural History), none probably possess greater interest to the naturalist and comparative anatomist than the remains of the very remarkable group of aquatic phytophagous mammals known as the Sirenia, of which the "Manatee" and the "Dugong" are the living representatives.

Fossil remains of Sirenians have been met with in Tertiary strata over the greater part of Europe, in England, Holland, Belgium, France, Germany, Austria, Italy, and in deposits of analogous age in the Isthmus of Suez at Chalaif, and the quarries of Mokattam near Cairo, in Africa.

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[1] Graptolites of the Quebec Group, Montreal, 1865.

[2] Ann. Mag. Nat. Hist. ser. 4, vol. xi. (1873), pp. 133—143.

[3] Ann. Mag. Nat. Hist. ser. 4, vol. xiv. (1874), pp. 1—9.

[4] Prodromus of the Palæontology of Victoria, Dec. i.—iii. (1874—78).

They have also been obtained from the Phosphate Beds of South Carolina, the Eocene of Shark River, New Jersey, in the United States; and from the Tertiary of Jamaica in the West Indies.

Of the European species, by far the larger number are referable to the genus *Halitherium*, originally described by Kaup from the Miocene of Hesse-Darmstadt, and of which we are now, thanks to Dr. G. R. Lepsius, of the Museum, Darmstadt, acquainted with the entire skeleton (Fig. 1).

[See the Memoir on *Halitherium Schinzi*, die fossile Sirene des Mainzer Beckens, von Prof. Dr. G. R. Lepsius, Darmstadt, 1881, Abhandl. des Mittelrhein. geolog. Vereins, 1 Band, 1 Lieferung, pp. 1—76, with 10 double quarto plates.][1]

Halitherium resembled the Dugong in its dentition, having small tusk-like incisors in the upper jaw, though these were not so well developed as in the 'Dugong' (*Halicore*). The molar teeth were $\frac{5}{5}$ or $\frac{6}{6}$, the anterior teeth were simple and single-rooted, the posterior teeth of the upper jaw with three roots, and those below with two roots, and with enamelled and tuberculated or

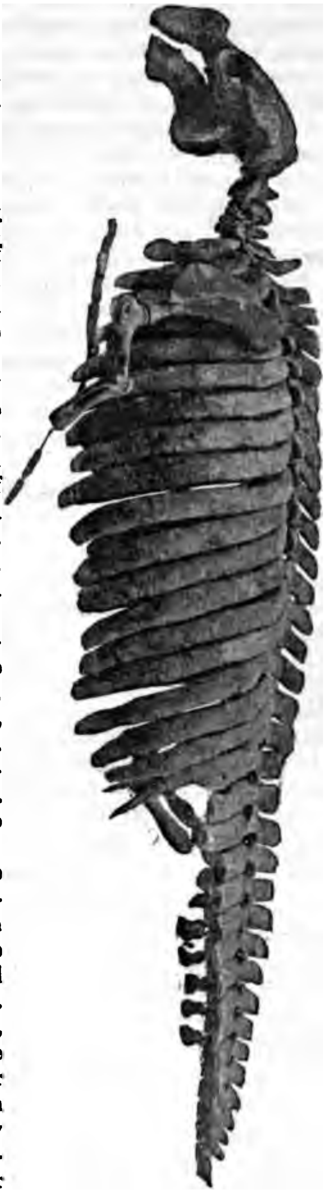

Fig. 1.—Skeleton of *Halitherium Schinzi*, Kaup, from the Miocene of Darmstadt. Reproduced from the restored skeleton preserved in the Museum at Darmstadt, a cast of which is placed in the Geological Galley of the British Museum (Natural History), Cromwell Road. Length of skeleton, 7 feet 8 inches.

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[1] Numerous remains of *Halitherium*, comprising two jaws, one skull, detached teeth, scapulæ, femora, ribs, and many vertebræ, from Darmstadt, are also preserved in the collection.

ridged crowns, in all which points they resemble the Manatee more than the Dugong. The anterior molars were deciduous.

The pelvic bones are better developed than in existing Sirenians; there is also a rudimentary styliform femur. They were therefore less specialized than their modern representatives (Flower).

Fifteen species of fossil Sirenians have been referred to the genus *Halitherium* (see list pp. 424–5),

Only one species, *Halitherium Canhami*, Flower, from the Red Crag of Waldringfield, Suffolk, occurs fossil in England. (See Quart. Journ. Geol. Soc. 1874, vol. xxx. pp. 1-7, pl. i.)

This interesting species is represented by a coloured cast of the skull in the British Museum (Natural History), the original being preserved in the Ipswich Museum.

Another genus, very considerably larger than *Halitherium*, has been described by Professor Giovanni Capellini, from the Pliocene of Riosto, Bologna, under the name of *Felsinotherium Forrestii*; it consists of a nearly perfect skull and lower jaw, of which the British Museum (Natural History) also possesses a coloured cast of the type specimen.

Felsinotherium closely resembles *Halicore* in its dentition:

$$\text{incisors } \frac{1\ \ 1}{0\ \ 0} \qquad \text{molars } \frac{5.\ \ 5.}{5.\ \ 5.}$$

Another species of *Felsinotherium*, namely, *F. Gervaisii*, has also been described by Prof. Capellini from the Pliocene of Siena.[1]

The skull and lower jaw of a very singular type of Sirenian, named by Prof. Sir Richard Owen *Prorastomus sirenoides*, has been obtained from strata of Tertiary age in Jamaica, and is preserved in the British Museum (Natural History).

It differs widely from either known existing or extinct genera of Sirenia, but probably approaches nearer to the living *Manatus* than to *Halicore*. But it is in its dentition that *Prorastomus* presents the most remarkable deviation from the rest of the order, for we have present at one and the same time, clearly differentiated—

$$\text{incisors } \frac{3-3}{3-3},\ \text{canine } \frac{1-1}{1-1},\ \text{premolars } \frac{5-5}{5-5},\ \text{molars } \frac{3-3}{3-3} = 48 \text{ teeth.}$$[2]

Another curious discovery is that of a natural acst, found by Dr. Grant of Cairo, in a block of Eocene (?) rock from the quarries of Mokattam, near Cairo, which proved to be a most perfect copy of the interior of the skull or brain-cavity of another species of Siren, named *Eotherium Ægyptiacum* by Owen, who described it in the Quarterly Journal Geol. Soc. for 1875 (vol. xxxi. p. 100). Portions of the characteristic ribs and some detached teeth have also been obtained from the same locality. This natural cast of the brain of *Eotherium* is placed with the other fossil *Sirenia* in the Geological Gallery of the British Museum (Natural History).

Early in the present year, the Trustees acquired by purchase, from Mr. Robert Damon, F.G.S., a nearly entire skeleton of *Rhytina gigas*[1] (=*Rhytina Stelleri*[2]) obtained from the Pleistocene Peat-deposits on Behring's Island.

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[1] See Mem. dell'Istit. di Bologna, ser. iii. tom. i. fasc. 4, pp. 605—634, tav. i—vii.

[2] See Quart. Journ. Geol. Soc. 1855, vol. xi. pl. xv. figs. 1—6, and 1875, vol. xxxi. pp. 559—567.

This interesting species of Siren, commonly known as "Steller's Sea-cow," once no doubt abundant along the shores of Kamtschatka, the Kurile Islands, and Alaska peninsula, but now entirely extinct, was first discovered by the eminent German naturalist Steller, who, in company with Vitus Behring, a captain in the Russian Navy and a celebrated navigator of the northern seas, was with his vessel and crew cast away upon Behring's Island (where Behring died), in 1741.

We have fortunately preserved to us Steller's original description[3] of the animal, as seen alive by him, during his long enforced residence on the island; and no other competent observer has since had the same opportunity; for between 1742 and 1782, a period of forty years, this large and harmless mammal appears to have been entirely extirpated, for the sake of its flesh and hide, around both Behring's Island and Copper Island, to the shores of which in Steller's time it was limited.

In his recently published "Voyage of the Vega," Professor A. E. Nordenskiöld[4] has drawn attention to this now extinct Sirenian, and by the description of his efforts to recover its remains, we learn much as to their present rarity, whilst he graphically portrays the habits of *Rhytina* and its general appearance, as gathered from the bibliographical notices given by Steller, who alone seems to have left any record of the living animal.

The bones of the *Rhytina* are not be seen anywhere lying upon the surface of the ground in either of the two islands, nor do they occur along the shore at the level of the sea, but they are met with at a distance from the shore in old raised beaches and the Post-Tertiary peat-mosses, deeply buried and thickly overgrown with luxuriant grass. It would be next to impossible to find them by digging, but they are found by boring into the peat with an iron rod or some such tool. The same method is adopted in the peat-deposits in Ireland, when one desires to find a timber-tree for gate-posts; or when seeking for remains of the gigantic Irish Deer, *Cervus hibernicus*; the resistance offered to and the sound emitted by the boring-rod, when in contact with a solid, is at once noticed by the operator. The specimen of *Rhytina* now in the British Museum was obtained from compact peat, and all the vertebræ and other bones having cavities in them were full of peat-growth when they arrived, as was also the skull.

Although specimens of *Rhytina* are preserved in several Museums, as at St. Petersburg, at Helsingfors in Finland, and in Stockholm, the acquisition of an almost perfect skeleton for the British Museum (Natural History) appears deserving some special notice.[1]

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[1] Zimmermann, 1780.

[2] Desmarest, 1819.

[3] "De Bestiis marinis, auctore Georg. Wilhelm. Stellero," etc., Mém. Acad. Sci. St. Pétersbourg (read 1745, published 1751), tom. ii. pp. 294–330.

[4] "The Voyage of the Vega round Asia and Europe," London, 1881, vol. ii. pp. 272–281.

A detailed description of the *Rhytina* is rendered almost supererogatory by the magnificent work of the late Dr. J. F. Brandt, of St. Petersburg,[2] who in his Monograph, 'Symbolæ Sirenologicæ,' 1846–68, has left us a masterly and detailed account of the anatomy of this interesting genus, accompanied by admirably executed plates.

The head in *Rhytina*, and indeed in all the Sirenia, is rounded, and of moderate size, never disproportionately large, as in the Whales; the neck is short and scarcely offers any marked constriction between the head and body. But, although short, the neck is capable of a considerable amount of movement, which is not the case in any of the Cetacea, with which group the Sirens were formerly confounded.

The muzzle is truncated and obtuse, and the nostrils, which are placed above the fore part of the snout, are valvular and distinct. The external ear is absent, or very small; the eyes very small with an imperfect eyelid, but a well-developed nictitating membrane. The form of the body is depressed, fusiform, tapering behind, and without any dorsal fin; the tail is flattened and expanded horizontally, as in the Cetacea.

The fore limbs appear to be remarkably free, and capable of being moved from the shoulder-joint. Thus the living Manatee has been observed to use its fore limbs, "manus," to assist in bringing the food towards the mouth in feeding; and, as the mammary glands are axillary, the females all hold the young, in early life, under their arms.[3]

The pelvis in the Sirenia is exceedingly rudimentary, consisting of a pair of small bones suspended at some distance below the vertebral column. (These have not been observed in *Rhytina*.) There is no trace of any hind limb; but a *rudimentary femur* has been noticed in another extinct form of Sirenian (*Halitherium*).

The head in *Rhytina* is small in proportion to the long and very thick body. The bones of the skull are massive, but very loosely connected together.

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[1] The first account of this acquisition was read before the Geological Society of London, 25 March, 1885, entitled:—"On an almost perfect Skeleton of *Rhytina gigas* (*Rhytina Stelleri*, 'Steller's Sea-cow'), obtained by Mr. Robert Damon, F.G.S., from the Pleistocene Peat-deposits on Behring's Island. By Henry Woodward, LL.D., F.R.S., F.G.S., etc.," and appeared in the Quart. Journ. Geol. Soc., 1885, August No. vol. xli. pp. 457–472. A portion of this article, together with two of its illustrations, is, by permission of the President, reproduced here.

[2] One of the contemporary writers on *Rhytina* with Brandt, after Steller, was Alexander v. Nordmann, Professor of Zoology in the Imperial University of Helsingfors, in Finland (see Beiträge zur Kenntniss des Knochen-Baues der *Rhytina Stelleri*, von Dr. Alexander v. Nordmann, 4to. Helsingfors, 1861, Acta Soc. Scient. Fennicæ, tom. vii. with 5 plates).

[3] That the appearance of these grotesque animals, no doubt frequently seen by the earlier voyagers, both in the East and West Indies and on the coasts of Africa, should have originated the legends of Mermaids and Sirens, seems at first sight incredible; but art was then in its infancy in this country, and doubtless the engraver, who portrayed at *second hand* the features of the "sea-siren," had but little assistance in his delineation from the narrator.

Sir Richard Owen observes that this character of the skull, taken in connection with the density of the bony skeleton, and the absence of cavities[1] in the bones themselves, reminds one of the skeleton of the Reptilia (Owen, "On the Dugong," Proc. Zool. Soc. 1838, pp. 28–45).

The nasal bones are quite rudimentary; the maxillary border is narrow and straight; the premaxillary bones, forming the rostral portion of the skull, are long and considerably developed in front, forming the strongly curved border of the nasal opening, and projecting with a downward curve (as in *Halicore*, but less acute), its upper and outer contour being very convex, and the lower and inner palatal surface being concave.

The zygomatic arch is strongly developed and much curved. The occipital portion of the skull is the broadest; the supraoccipital portion is very rugose, the condyles are semicircular and prominent, and the foramen magnum is very wide.

The lower jaw is deep in proportion to its length. The coronoid process rises very little above the condyle itself. The symphysis of the mandible extends for about one-third (or rather more) of its length, having a convex contour on its upper surface to correspond with the concave contour of the premaxilla. The symphysial surface is very rugose.

Two kinds of teeth (molars and incisors) are usually present in most of the Sirenia.[2] Dr. James Murie, in his elaborate and exhaustive memoir on the Manatee (Trans. Zool. Soc. vol. viii. 1872, pp. 127–202, pl. xvii.–xxvi.), observes:—"Although *Rhytina* was edentulous in the adult condition, I strongly suspect that, like other Sirenian genera, *rudimentary teeth* may have existed in its earlier stages of growth. Nordmann seems also favourably inclined to this opinion."

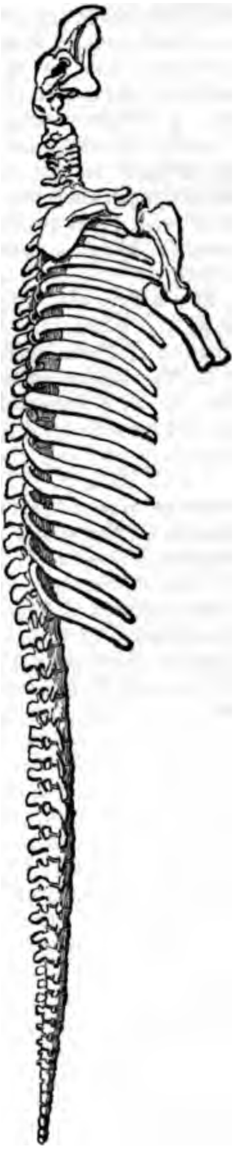

FIG. 2.—Outline-sketch of Skeleton of the Extinct *Rhytina gigas*, Linn. = *R. Stelleri*, Desmar. From Behring Island. The original preserved in the British Museum (Natural History). (Length 19 feet 6 inches.)

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[1] *Ornithopsis Seeleyi*, Hulke, had not then been discovered.

[2] In *Prorastomus* canines are also developed; but *Rhytina* possessed neither.

It is interesting to observe, in confirmation of Dr. Murie's observation, that the skulls of *Rhytina* in the British Museum demonstrate the former presence of small rudimentary incisor teeth in the premaxillaries, two small alveoli being clearly shown; and the sides of these bones are swollen slightly, just where the pulp-cavities of these small incisors would have been situated.

As compensation for the absence of teeth in *Rhytina*, the palate and sides of the gums of both the upper and the lower jaw were covered by tough corrugated horny plates, of peculiar structure, which assisted in the process of mastication.

With regard to the structure of the palatal and mandibular laminæ, although their function was undoubtedly that of the trituration of food, Prof. Brandt has shown[1] that they are destitute of true bony or dental substance, and that they are in fact indurated epithelium.

Dr. Murie has also expressed his conviction that the strongly ridged palatal plate in *Rhytina* is homologous with that found in *Manatus* and *Halicore*. "It certainly," he adds, "does not appear to me to be the representative of teeth, nor of the *baleen* plates met with in the true Cetacea." "The maxillary alveolar ridges are narrow and quite behind the *bruising-plate*, the latter occupying the intermaxillary and not the maxillary bones" (Murie, Trans. Zool. Soc. vol. viii. 1872, p. 167).

Advantage was taken of the loose and readily separable state of the sutures of the skull, to make a careful gelatine mould of the brain-cavity. The result is shown in the cast exhibited in the Collection, which differs somewhat from the figure (similarly obtained) of the brain-cavity of *Rhytina* taken by Brandt.

A comparison of the cast of the brain with that of other Sirenia tends to the conclusion that the brain of *Rhytina* was intermediate between that of *Halicore* and *Manatus*. It is interesting to observe that the brain of *Rhytina*, considering the huge size of the body of the animal, seems to be only one-sixth of the size of that of the living *Manatus* or *Halicore*. This agrees with Prof. Marsh's observations on the smallness of the brain in Tertiary mammals,[2] and is strongly favourable to the very high antiquity of *Rhytina*. The plaster cast of the brain of *Rhytina* exhibits traces of the small optic nerves, and of a very large fifth hypophysis showing a rounded prominence.[3]

The bones of the ear of *Rhytina Stelleri*, namely, the os petrosum of the periotic, with the tympanic annulus, are preserved on both sides of the skull. On removing the peat from the cavity of the mid-ear, Mr. C. Barlow (the able *formatore* of the Geological Department) discovered the three small auditory ossicles, namely, the *Stapes*, *Incus* and *Malleus*, still within the cavity. They agree very closely with the figures given by Brandt,[1] and are also near to the ossiculæ auditus of the Manatee.

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[1] Brandt, Mém. Imp. Acad. Sci. St. Pétersbourg, 1846, vi. série, pt. ii. Sci. Nat. vol. v. livr. iv. pp. 1-160, tab. i.-v.

[2] See Marsh in Silliman's Journal, "On the small size of Brain in the Tertiary Mammalia," 3rd series, vol. viii. 1874, p. 76, *ibid. op. cit.* vol. xii. 1876, p. 61 and vol. xxix. 1885, pp. 190-193.

[3] Brandt, "Symbolæ Sirenologicæ," fasc. iii. 1878, p. 256. Tab. ix. Mém. de l'Acad. Imp. d. Sc. St. Pétersbourg, sér. vii. tom. xii.

The sternum in *Rhytina* is a rather irregularly-shaped bone, not very symmetrical bilaterally; it has been figured by Brandt, and a portion of one is preserved with the skeleton now in the British Museum. It is a much thicker and stronger bone than the sternum of the Manatee, but is similar in form.

The scapula is somewhat convex externally, the inner concave face fitting closely against the anterior ribs to which it was attached; the spinous process of the scapula is strongly developed. The glenoid cavity is deep and circular and well fitted to the rounded head of the humerus; the humerus is short and very stout; the radius and ulna, which are also short, are anchylosed together at both extremities and incapable of any rotatory motion; the olecranon is strongly produced and curved, showing that the fore arm as well as the humerus had considerable free lateral movement for the act of swimming.

The carpal bones and digits of the manus of *Rhytina* are unknown; the digits were probably five, as in *Manatus* and *Halicore*, but the thumb in the latter is rudimentary. Externally viewed, the fore limb in *Rhytina* was fin-like, with no separate digits or nails visible; but Steller describes their extremities as thickly covered with short bristly hairs.

The skeleton is remarkable for the massiveness of the bones, especially the great density of the ribs, which have the hardness of ivory. This extreme density of the ribs is a character also shared by the modern Manatee and Dugong, and by the extinct *Halitherium* and *Felsinotherium*. There is a general absence of medullary cavities in the bones.

The great specific gravity of the bones no doubt assisted these animals in keeping their bodies sunk beneath the surface of the shallow waters in which they dwelt whilst feeding upon the marine vegetation upon which they wholly subsisted.

Although the normal number of cervical vertebræ maintained in the Mammalia is usually seven, yet some variations are met with, as, for example, in the "American Manatee," which has only *six*. Conversely in *Bradypus* the number of the cervical vertebræ is increased to *eight or nine*. This is explained by the fact that the thoracic vertebræ in *Bradypus* pass into the cervical region, while the diminution to six in *Cholœpus* and in the American Manatee is similarly explained by the complete development of the rib of the seventh cervical vertebra.

Rhytina has been described by Steller as only possessing six cervical vertebræ, like the Manatee; but Brandt correctly gives the number as seven, and the specimen now in the Museum confirms this determination.

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[1] Brandt, "Symb. Siren." Fasc. ii. pp. 8–10, Tab. ii. figs. 11–20. Mém. Acad. Imp. Sci. St. Pétersbourg, sér. vii. 1861. See also Claudius "On the Organs of Hearing in *Rhytina*," Mém. Acad. Imp. Sci. St. Pétersbourg, 1867, vol. xi. No. 5, 2 plates.

The atlas- and axis-vertebræ in *Rhytina* are fairly robust, and the atlas is as broad as the second dorsal vertebræ; but the five remaining cervical vertebræ, although quite free, are thin and plate-like, as in the Cetacea proper. But the Sirenia are distinguished from the true Whales by their capability of moving the head from side to side, and up and down, by means of the "odontoid process" of the axis vertebra on which the head rotates. In the Cetacea, in which the cervical vertebræ are anchylosed together to a greater or less extent, and the neck is consequently immovable, the odontoid process is also wanting.

As the Sirenia spend their whole lives browsing upon the *Laminariæ* and other Algæ and aquatic plants, this power to move the short neck pretty freely must be essential to them both in feeding and also in putting up their heads to breathe.

The number of vertebræ attributed to the Sirenia, both of living and extinct genera, is very variable according to different authors. Prof. Brandt attributed to *Rhytina* 7 cervicals, 19 thoracic or dorsal vertebræ, and from 34 to 37 lumbar, sacral, and caudal. The cervicals and dorsals are readily determined; but, as none of the vertebræ are anchylosed together to form a sacrum, it is a matter of some difficulty to decide which are lumbar and which are sacral vertebræ.

Not only does anchylosis never occur in the vertebræ of the Sirenia, but the flat ends of the centra of the vertebræ *do not ossify separately* so as to form dish-like epiphyses in the young state, as is commonly the case in all the other Mammalia.

Brandt indicates the 7th vertebra beyond the last of the dorsal or thoracic series as bearing the rudimentary pelvis; but as the vertebræ are never *anchylosed* to form a sacrum, we can only conjecture (by noticing a slight prominence upon the posterior border of the extremely wide transverse processes) which of these lumbar-sacral vertebræ seem marked as sacral, probably about the 5th, 6th, and 7th. The 13 vertebræ next behind the dorsal series may, from their size and their wider and longer transverse processes, be considered lumbar and sacral, and the 21 following vertebræ as caudal; about 6 or 8 of the most anterior of the latter had small V-shaped chevron bones or hæmal arches attached to them in the St. Petersburg specimen.

The transverse processes in the caudal series are much smaller, thicker, and shorter, and are directed obliquely backwards.

There is a marked variation in the form and size of the neural arch and the centrum of the several vertebræ in the spinal column, from before backwards. The anterior dorsal vertebræ have each a small compressed centrum, much broader than deep; the neural arch is triangular, the neural spine erect.

From the 5th to the 8th dorsal the centra are longer and cordiform, and the neural canal is smaller and more rounded: the neural spine bends backwards, and the zygapophyses are more prominent.

The lumbar vertebræ are much dilated laterally, the centra being nearly three times as broad as deep. The neural canal is reduced in size, and the neural spine is moderately large; but the transverse processes are very flat, long, broad and straight, being in relation to the centrum as 5 to 1.

The centra of the caudal vertebræ are rounder, the transverse processes are short and stout and bent backwards; the neural canal is reduced to a very small size, and the neural spine gradually disappears.

The 11th to 16th thoracic or dorsal vertebræ have irregularly developed hypapophyses on the ventral surface of their centra.

There are 19 pairs of ribs in *Rhytina*, probably not more than two pairs of which were articulated to the sternum. The 1st and 2nd pairs are short and much compressed laterally, the third and following are round and very massive, and increase in curvature and length up to the 12th, when they gradually become shorter and less curved, the 19th being quite rudimentary.

The ovoid visceral cavity thus inclosed within the bony walls of the ribs is of vast dimensions; and one realizes readily the statement that a full-grown male, covered with its integument and flesh, weighed as much as 3½ tons.

This large number of rib-bearing vertebræ in the Sirenia is only equalled in *Elephas* and *Rhinoceros*, and only exceeded in *Dendrohyrax* (which has 22 costal vertebræ), thus affording an interesting point of analogy in *Rhytina* to the Ungulata.

Another point of comparison is observable in the teeth in *Manatus* and *Halitherium*, which have a most remarkable resemblance to the molars in *Hippopotamus*, *Mastodon*, and the Suidæ.

Dr. Murie strongly insists upon the dermal characters as offering a further close resemblance between *Manatus* and *Elephas*. The short (rudimentary) nasal bones and the prolonged premaxillaries. with their tusk-like incisors, afford additional points of resemblance with the Proboscidea.

The Sirenia pass their whole life in the water, being denizens of shallow bays, estuaries, lagoons, and large rivers; but they never venture far away from the shore. Their food consists entirely of aquatic plants, upon which they browse beneath the surface, as the terrestrial herbivorous mammals feed upon the green pastures on land.

When Steller came to Behring's Island in 1741, the Sea-cows pastured in the shallows along the shore, and collected in herds like cattle. As they fed, they raised their heads every four or five minutes from below water in order to breathe before again descending to browse on the thick beds of sea-weed which surround the coast.[1]

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[1] My colleague, Mr. William Carruthers, F.R.S., F.G.S., Keeper of the Botanical Department, informs me that the large sea-weeds called *Laminariæ* grow in water at or just below low-water; they are nutritious and are eaten by animals. They abound in the North Pacific Ocean. Ruprecht, in his account of the Algæ of the North Pacific, records eight species of these large weeds growing in the Sea of Ochotsk, on the shores of Kamtschatka, and the north of North America. He adds:—"When I went to see the Coniferous trees at Monterey, California, last autumn, I was surprised at the magnitude and quantity of the *Fuci* and *Laminariæ* thrown up on the coast."

They were observed by him to be gregarious in their habits, slow and inactive in their movements, and very mild and inoffensive in their disposition. Their colour was dark brown, sometimes varied with spots. The skin was naked, but covered with a very thick, hard, rugged, bark-like epidermis, infested by numerous parasites. One of these, the *Cyamus Rhytinæ*, has been described and figured by Prof. Brandt.[1]

When full-grown, they are said to have sometimes attained a length of 35 feet and a weight of 3 or 4 tons.

Like most of the Herbivora, they spent the chief part of their time in browsing. They were not easily disturbed whilst so occupied, even by the presence of man. They entertained great attachment for each other; and when one was harpooned, the others made incredible attempts to rescue it. They were so heavy and large that, Steller records, they required 40 men with ropes to drag the body of one to land.

If we compare the extinct *Rhytina* with the existing forms of Sea-Sirens, we shall see that it approaches most nearly to the Dugong (*Halicore*), which when adult has only one pair of incisors left in the upper jaw, and two (rarely three) molars on each side above and below, making 14 teeth in all.

But adding the milk-dentition, we have in *Halicore*:—

$$\left.\begin{array}{l}\text{Milk-dentition}\\[1em]\text{Permanent teeth}\end{array}\right\}\text{Incisors.}\quad\begin{array}{c}\dfrac{1-1}{3-3}\\[1em]\dfrac{1-1}{0-0}\end{array}\quad\text{Molars.}\quad\begin{array}{l}\dfrac{3-3}{3-3}\\[1em]\dfrac{2-2}{2-2}\text{ rarely }\dfrac{3-3}{3-3}\end{array}$$

The teeth in *Halicore* are more or less cylindrical; the incisors, in their form and wear, resemble those of the Hippopotamus. The last molar is compressed laterally, giving the crown a figure-of-eight shape; but there is no distinction into root and crown. The summits of the crown are tuberculated before wearing; afterwards they are flattened or slightly concave.

After the milk incisor-teeth of *Halicore* are shed, their alveoli, along the anterior half of the mandible, are covered over with a thick horny epithelium, which serves in the adult as a bruising-plate in lieu of the anterior teeth, as is the case in *Rhytina*.

In *Manatus senegalensis* the only milk-teeth present are the incisors, $\frac{1-1}{1-1}$, which speedily disappear; but the molars amount to $\frac{11-11}{11-11}=48$ in all. The upper molars have two ridges and three roots; the lower mandibular series have an additional posterior ridge or talon, and only two fangs.

The teeth drop out in front, and are renewed from behind as in the Proboscidea.

This extreme variation in the number of the teeth from 2 (milk-incisors) in *Rhytina*, to 48 teeth in *Manatus*, is exactly paralleled in the Cetacea, in which we have many edentulous species (Balænidæ); others with only two teeth present (Ziphioid Whales); others again with very numerous teeth (Delphinidæ).

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[1] "*Cyamus Rhytinæ*." Mém. Acad. St. Pétersb. 1871, vol. xvii. No. 7; and Ann. and Mag. Nat. Hist. 1872, pp. 306-313.

All the earlier voyagers confounded the Southern Sirenia with the Seals, and the *Rhytina* with the Morse or Walrus. In 1811, Illiger separated the three genera—*Manatus*, *Halicore*, and *Rhytina*, under the name Sirenia, and placed them between the Seals and the Cetacea. They are now placed by Prof. Flower and other naturalists between the Ungulata and the Cetacea.

The following conclusions in reference to the Geographical Distribution of the order SIRENIA appear to be worthy of the special attention of geologists and palæontologists.

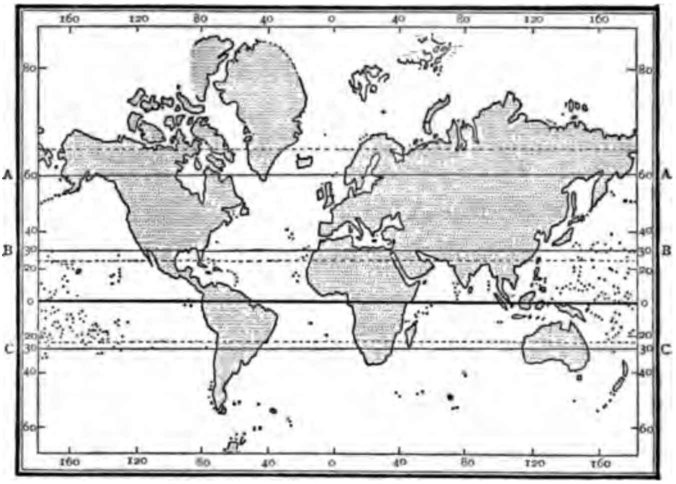

FIG. 3.—Map illustrating the Geographical Distribution of the order Sirenia.
AA. Line of extreme Northern distribution of the SIRENIA in Tertiary times.
BB. to *CC.* Limits of distribution of existing species of Sirenia.

If we take the belt of the tropics, that is, 23½° N. and 23½° S. of the equator (or, better still, say 30° N. and S. of the equator), *we shall embrace the geographical area of all the living Sirenians.*

If we take another belt of 30° *North beyond the tropic of Cancer*, we shall embrace *the whole geographical area in which fossil remains of Sirenians have been met with.*

Assuming, as I think we may, that the Sirenia at the present day *belong exclusively to the tropical regions of the earth*, and that *Rhytina*, in its boreal home, was simply a surviving relic from the past (a sort of geological "*outlier*," as of a stratum elsewhere entirely denuded away), we must conclude that the presence of about 12 genera and 27 species of fossil Sirenia, as widely distributed then as the recent forms are at the present day, *but with a range from the tropic of Cancer up to* 60° *of north latitude*, affords a most valuable piece of evidence (if such were needed), attesting the former northern extension of subtropical conditions of climate which must have prevailed over Europe, Asia, and N. America, in Eocene and Miocene times and in the older Pliocene also.

The early appearance of so highly modified a form of mammal, its abundance, wide distribution, and variations, serve to attest the great lapse of time occupied in the accumulation of even our later Tertiary deposits, which we are sometimes apt to pass over as representing but a very brief chapter in the geological history of our earth; and further, it must necessitate our carrying back the Mammalian class not only far back into Secondary, but probably even into Palæozoic, times.

The following is a List, with their distribution, of the *existing species* of the order SIRENIA.[1]

Manatus senegalensis, Desmarest (the African Manatee), inhabiting the west coast of Africa from about 16° N. to 10° S. lat., with the rivers Senegal and Congo, and as far into the interior as Lake Tchad; and, according to native accounts, to the River Keebaly, 27° E. long.

Manatus latirostris, Harlan (the West Indian Manatee), inhabiting the creeks, lagoons, and estuaries of the West Indian Islands and coast of Florida.

Manatus americanus (the Brazilian Manatee), inhabiting the coast as far south as about 20° S. lat., and the great rivers Amazon and Orinoco, almost as high as their sources.

Halicore tabernaculi (the Dugong), inhabiting the Red Sea and the East Coast of Africa.

Halicore dugong, inhabiting the Indian Sea, Ceylon, Bay of Bengal, Indo-Malayan Archipelago, and Philippine Islands.

Halicore australis, the coasts of Eastern and North Australia.

In addition to the fossil genera met with in Europe, we have the *Prorastomus sirenoides* of Owen (already referred to) occurring in the West Indies; a form of Sirenian having important differences in dentition, by which to separate it from the now living *Manati*. Three other species occur in the Tertiary beds of South Carolina; and a doubtful form in the deposits of Darling Downs, Queensland, Australia.

Lastly, there is the great extinct *Rhytina* of Behring's Island. We have, then, at the present day living in America, Africa, India, and N.E. Australia, two genera and six species of Sirenia; and in Europe, Asia, Africa, and America, 13 genera and 30 species of extinct Sirenians.

LIST OF FOSSIL SIRENIA, WITH THEIR FORMATIONS AND LOCALITIES:—

Chirotherium subapenninum, Bruno, 1839. Pliocene: Piedmont.
Chronozoon australe, C. W. de Vis. Pliocene: Darling Downs, N. S. Wales. (cast of the *calvarium* only).
Crassitherium robustum, Van Beneden. Pliocene: Belgium.
Diplotherium Manigaulti, Cope. Miocene?: S. Carolina.
Eotherium ægyptiacum, Owen. Eocene?: Mokattam, Cairo.
Felsinotherium Forestii, Capellini, 1872. Pliocene: Riosto, Bologna.
——— *Gervaisii*, Capellini, 1872. Pliocene: Siena.

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[1] Dr. J. Murie, F.L.S., who has specially studied this group, has expressed his opinion to the writer that there are probably only two distinct species of *Halicore* and *Manatus* living at the present day; and that the large number of fossil species described are probably also capable of being reduced at most to two or three genera and species.

Halitherium Serresii, Gervais. Pliocene: Montpellier; d'Estrés (Bouches-du-Rhône).
———— *fossile*, Cuv. sp. Miocene: St. Maure, Loire; Angers, Rennes, Morbihan.
———— *Beaumontii*, Christol, sp. Miocene: Beaucaire, Gard.
———— *Guettardii*, de Blainv. Miocene?: Etréchy (Seine), etc.
———— sp.
———— *dubium*, Cuv. Eocene: Blaye, Gironde.
———— *bellunense*, Zigno, 1875. Miocene: Belluno, Venetia.
———— *angustifrons*, Zigno, 1875. Miocene: Belluno.
———— *curvidens*, Zigno, 1875. Miocene: Belluno.
———— *veronense*, Zigno, 1875. Miocene: Belluno.
———— *Schinzi*, Kaup, 1855. Miocene: Darmstadt; Miocene: Malta.
———— *Canhami*, Flower. Crag (derivative): Suffolk.
———— *Cuvieri*, Owen. Miocene: Montpellier.
———— sp., Van Beneden. Miocene ("Bolderian"): Elsloo, near Maestricht.
———— (*Chirotherium*) *Brocchii*, Bruno (Owen, *cit.*). Miocene: Herault.
———— sp., Zigno. Miocene: Chalaif, Isthmus of Suez.
Hemicaulodon effodiens, Cope. Eocene: Shark River, New Jersey, U.S.
Manatus Coulombi. Filhol (1878) (named after M. Coulomb, the discoverer). From the Eocene? Quarries, Mokattam, near Cairo (founded on three teeth of lower jaw like the Manatee).
———— *inornatus*, Leidy. Miocene?: Phosphate beds, South Carolina.
Pachyacanthus trachyspondylus, Brandt (in part), Van Beneden, *emend.*, 1875. Miocene: Nussdorf, near Vienna. (Based on vertebræ and ribs of a Sirenian.)
Prorastomus sirenoides, Owen. Tertiary: Jamaica.
Rhytina gigas, Zimmermann (Geograph. Gesellsch. 1780). Pleistocene: Behring's Island, = *Rhytina Stelleri*, Desmarest, 1819.
Rhytiodus Capgrandi, Lartet. Pliocene: Basin of the Garonne.
Trachytherium Raulini, Gervais. Miocene: La Réole, Gironde.

V.—Note on the Genus Stenotheca.

By George F. Matthew, of St. John's, New Brunswick.

As facts relative to the earliest forms of Molluscs are of interest to the naturalist as well as the geologist, I offer this note on the genus *Stenotheca*, derived from a study of the remains of several species occurring in the Cambrian rocks of Canada. The formation in which they are found is the St.-John Group, a formation occurring in the Southern part of the Province of New Brunswick; and the geological horizons are those of the Solva and Menevian Groups of Wales, equivalent to the *Paradoxides-Tesseni* beds, and overlying measures of Étage 1, of the Norwegian geologists. The fossils are, therefore, of great antiquity, having preceded any known Lamellibranchs; and, except the *Metoptoma Barrandei* of Linnarsson, I know of no Gasteropods of equal antiquity.

The genus *Stenotheca* was proposed in 1872 by Dr. Henry Hicks, to include a minute corrugated shell found in the Menevian Group of Wales. It is described by Dr. Hicks as "a curved shell"—"a small wide form, with lines of growth strongly marked on its surface." The genus is represented in Division 1*d* of the St.-John Group by several small compressed species, none of which appear to be identical with *St. cornucopia*, the type of the genus.

Dr. Hicks places this genus in the Pteropods (Quart. Journ. Geol. Soc. May, 1875, p. 192). If I am right in referring our shells to his genus, there seem to be features which indicate greater affinities to the Heteropods and Gasteropods; but the order to which these fossils should be referred is still doubtful, and must await further knowledge. The little shells of this genus found at St. John are always inequilateral, and usually present a carina at the posterior (?) end, and not unfrequently at both ends. Among recent Molluscs, *Carinaria* and *Atlanta* are the forms which appear to come nearest to the species under consideration. In general outline the fossils are nearest the former genus, but in their compressed forms they remind one of the latter; from both, however, they differ in the straight, or nearly straight apex, and in the arrangement of the lines of growth on the shell. They resemble these genera in that the majority of the species have a keel along the back, and it seems probable also that in some of the species the shell consisted of two lateral plates imperfectly connected along the back, for the two sides are occasionally found detached, and one pushed past the other. The apex of two out of the five species in the St.-John Group is known, and does not show any tendency to a coiled form, as in *Carinaria*, *Atlanta*, or any other Heteropods, with which these fossils may be compared. Among certain genera of Gasteropods, however, as *Dentalium*, *Parmophorus*, and *Patella*, similar apices may be observed. These *Stenotheca* appear to have been denizens of the open sea, and have only been found in the fine dark shales of Division 1*d*, or about the horizon of the Menevian Group of Wales.

In the measures of Division 1*c* containing a fauna, the forms of which resemble those of the Solva Group, is a species of Mollusc, which, although agreeing with the typical *Stenothecæ* of Division 1*d*, shows important points of difference. This species, originally described as *Discina Acadica* by Prof. C. F. Hartt, exhibits relations with *Metoptoma* (?) *rugosa* of the Trenton limestone; it is much larger than the true *Stenothecæ*, and is preserved in a different attitude in the shales. The *Stenothecæ* are flattened on the vertical plane of the shell; but this species is found compressed horizontally, or parallel to the aperture; nevertheless, in their younger stages of growth these larger *Stenothecæ* show a tendency to collapse laterally, in this resembling the small shells of the overlying measures; in general form, also, as well as in the way in which additional concentric ridges are inserted at the back of the shell, these conform to their congeners in the horizon above.

Except for the absence of an involute apex, these shells are not unlike *Carinariopsis carinata*, Hall, of the Trenton formation; they are compressed near the apex in a manner similar to that species, and expand rapidly toward the aperture; but the arrangement of the lines of growth or surface-markings is quite different, and comparable with that of *Metoptoma* (?) *rugosa*, Hall. Our shells, however, are not *Metoptomæ*, since they are not truncated at the side beneath the apex, as are those of the Carboniferous genus *Metoptoma*. These patelloid *Stenothecæ* lived in shallow seas near the coast-line, if one may judge from the species of other genera associated with them.

St. John, N.B., *15th June*, 1885.

NOTICES OF MEMOIRS.

NOTICE OF A NEW LIMULOID CRUSTACEAN FROM THE DEVONIAN.[1]

By HENRY SHALER WILLIAMS, of the Cornell University.

AMONG the fossils collected last summer for a comparative study of the Devonian faunas, an interesting form was discovered in Erie County, Pennsylvania, worthy of special notice.

The specimen was found in a bluish sandstone (which in places is a fine pebbly conglomerate) at Le Bœuf called the "3d oil-sand," by Mr. I. C. White, in the Report Q 4 of the Second Geological Survey of Pennsylvania (p. 239), and regarded by him as the equivalent of the third oil-sand of the Venango oil-district of that State. In the same stratum and above it are typical Chemung fossils.

It occurs just at the junction between the sandstone and a stratum of soft, fine argillaceous shale, and, in the process of weathering, the fine shale has been washed away, leaving a sharply-defined cast of the fossil in hard sandstone, though no portion of the original crust is preserved.

The associated species are *Spirifera Verneuilii*, Murch. (= *Sp. disjuncta*, Sow.), *Rhynchonella contracta*, Hall; and in the shales just above the sandstone occur *Chonetes scitula*, Hall. "*Chonetes*" *muricata*, Hall, an *Ambocœlia umbonata*, Hall, a small Productus of the type of Hall's *Productella Boydii*, the coarse ribbed *Orthis Leonensis*, Hall, and a *Rhynchonella* agreeing with some of the wider forms of *R. sappho*, Hall.

The fauna is the characteristic Upper Chemung fauna of western New York and adjacent area. In this area some of the species occur among the earliest Chemung species; no characteristic Carboniferous types have been detected. The fauna may be considered, therefore, as a pure Devonian fauna.

The general form and structure of the specimen place it among the MEROSTOMATA with anchylosed thoracico-abdominal segments, but as only the under side is exhibited, its identification with *Prestwichia* must be regarded as provisional, since we are ignorant of the structure of the under surface of authentic members of that genus.

I propose as a name for it, *Prestwichia Eriensis*, sp. nov.

The following characters exhibited by the specimen are regarded as generic and as locating it in the genus *Prestwichia* of Woodward. (1), the elliptical head-shield; (2), the genal spines which proceed backward more directly than in any described species of the genus; (3), the thoracico-abdominal segments anchylosed to form a buckler, to which is attached (4) a long telson. The general outline of the whole animal resembles that of the modern *Limulus*.

The evidence of a solid thoracico-abdominal buckler is found in the continuous surface across the body, from which proceed four (visible) short marginal spines each side the telson, and upon which are seen at least eight narrow ridges running longitudinally to near the margin.

The remaining characters may be, in part, of generic value, but they constitute the distinctive characters of the species, as far as these can be made out from the specimen.

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[1] Silliman's American Journ. of Sci. vol. xxx. July, 1885, p. 45.

The under side of the body presents three well-defined tracts, viz. the cephalic shield, which is evenly rounded in front, and is laterally prolonged backward into two genal spines, which are nearly parallel with the axis of the body, and reach nearly to a point opposite the posterior margin of the buckler. The cephalic shield along the median line is about a third the length of the body; the space between the posterior margin of the cephalic shield and the anterior margin of the buckler, containing the region of the mouth and the gnathopods, and the thoracico-abdominal buckler, marked over the surface by longitudinal ridges, and by marginal spines, and terminating in a long stout telson. Traces of the gnathopods are seen, as also traces of the foliaceous appendages of the posterior feet, but in too imperfect condition for exact delineation. Just anterior to the position of the mouth is seen a shield-like elevation upon the edge of the cephalic shield, which has the appearance of an hypostoma. The condition of the specimen is not such as to give absolute certainty to this interpretation, though the symmetry of its form is strongly in favour of it. It is possible that it is merely outlines upon the surface, produced by crushing during fossilization. There are faint indications of joints on each of the anterior set of gnathopods.

Along the centre of the thoracic region, there is a flattened depression, traversing longitudinally from the anterior edge of the plate, backward to the middle of the telson.

The terminal portion of the telson is evenly rounded. Each side of the median line of the buckler there are visible four clearly-defined marginal spines; there were probably more of them—six, I have supposed, but concealed in the specimen by the filling between the buckler and genal spines.

There are also four rounded, longitudinal ridges on the buckler each side of the flattened depression; these begin abruptly near the anterior margin of the buckler, and run almost directly backwards, tapering to a slender point near the margin of the buckler.

At the anterior margin of the buckler is a narrow plate, divided into a median and two lateral parts, which appears to be separated from the buckler itself by a distinct furrow. Laterally this plate appears to curve inwards and lies below (within) the surface of the buckler, and the median portion extends forward to a blunt point. I have interpreted this as probably representing the consolidated lamellar appendages of the "first and second" thoracic segments of *Eurypterus* as defined by Hall in Palæontology of New York (vol. iii. p. 398).[1]

The telson is nearly two-thirds the length of the body, is flattened at the base, but nearly cylindrical and tapering to a blunt point at the extremity.

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[1] If these indications are the remains of lamellar appendages, they are like those of *Limulus*, and may be compared with the generative plate and branchigerous thoracic appendages of the XIPHOSURA.—H. W.

Above are given all the characters of which the specimen presents any reasonable suggestion. I have ventured to put an interpretation upon some of the characters for which the evidence is slight, in the hope that those possessing specimens of any kindred forms may throw light upon this one by confirming the interpretation here given or suggesting a better one.

Dimensions:—

Total length	10 centimètres.
Greatest width	5·7
Length of telson (about)	4·0
Length of buckler (about)	2·0
Greatest thickness of telson	0·7

Horizon.—Chemung Group, Upper Devonian; the "third oil sand" of I. C. White, 2nd Pa. Survey.

Locality.—Le Bœuf, Erie County, Pennsylvania.

The original specimen is among the collections of the U.S. Geological Survey, and will be deposited ultimately in the National Museum.

Comments.—This specimen throws back the known range of *Prestwichia*, or at least the type to which this genus belongs, to an earlier stage than heretofore reported. The earliest previously known *Prestwichia* occurs in the Carboniferous.

If my interpretation of its characters be correct, *Prestwichia* bears closer relations to *Limulus* than is suggested by other known specimens, and also it possesses features linking it with Trilobites and Eurypterids.

[The author illustrates his paper by a photo-engraving from a drawing, of *P. Eriensis*, of the natural size, and two diagrammatic figures of the supposed upper and under surface. The specimen, although of great interest, is too obscure to permit us to draw any positive conclusions from it, save the fact of the important discovery of a Limuloid Crustacean in rocks of Devonian age in Pennsylvania. A still earlier Limuloid form has, however, been met with in the Upper Silurian of Lesmahagow, Lanarkshire, and described by the writer under the name of *Neolimulus falcatus*, H. W., see GEOL. MAG. 1868, Vol. V. pp. 1–3, Plate I. Fig. 1.—H. W.]

REVIEWS.

THE PALÆONTOGRAPHICAL SOCIETY. A MONOGRAPH OF BRITISH FOSSIL BRACHIOPODA.[1] By THOS. DAVIDSON, LL.D., F.R.S.

WITH the present appendix (vol. v. part iii.) a monumental work has been brought to a close.[2] The labours of Thomas Davidson, LL.D., F.R.S., need no introduction to Paleontologists of any part of the world. The quiet distribution of the concluding fasciculi of the "British fossil Brachiopoda" should not be allowed to pass without notice.

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[1] Science, vol. v. p. 409, 1885.

[2] There is, we understand, a Bibliography of the Brachiopoda ready for issue in the volume for 1885, by Dr. Davidson, which equals the work in its proportions and exhaustiveness.

Thirty years have passed since the publication of the general introduction to the first volume of this Monograph. Coincidently with, and largely induced by, its progress, a vast amount of precise knowledge has been acquired and made public, in regard to all that relates to the history and distribution of the Brachiopoda. Indeed, our knowledge of them, in any sufficient sense, may be almost said to date from about the time when the learned author began his labours; and the earliest known reference to them in any printed work dates only from 1606. The present appendix closes a series of researches, begun just half a century ago, on the Brachiopoda of the British islands. During that period, Dr. Davidson has not only prepared the text of his monograph, and numerous collateral and frequently very important papers on the general subject, but has drawn with his own hand more than two hundred admirable and artistic plates by which that text has been illustrated and adorned. Seldom has fortune equipped more completely a student for his life-work than in the present case, when more than ordinary artistic talent, a liberal education, independent means, were joined to unsurpassed devotion in the pursuit of knowledge, and impartiality in the recognition of the labours of others in the same field.

The steady stream of information induced by the publication of successive parts of the monograph has necessitated supplement after supplement. The present and concluding part not only contains such material, but a catalogue of, and index to, the British genera and species, bibliographical and stratigraphical, and, more important than either for the general biologist, a summary of progress in our knowledge of the class up to the present time. This includes notices, under separate heads, of the test, the embryology, the affinities, the adult anatomy, habitat, and ranges in depth, of recent species, characters of the fossil genera, and classification discussed by families. Full space is allotted to the advocates of contending theories: Kowalevski's valuable paper on the embryology is given in full abstract, with excellent figures; various suggested pedigrees are quoted; the brilliant rise, and slow but continuous decadence, of the "worm theory" is related, with generous recognition of the sagacity of Morse in the detection of affinities to which the then imperfect knowledge of the molluscan pedigree, and his remarkable researches into the early stages of Terebratulina and Lingula, lent a plausible, but, as it has since proved, a one-sided interpretation. The general conclusion is reached, that, however great the probability of continuous descent, with modification, as an explanation of the various forms of Brachiopods now or previously existing, the palæontological record presents many facts inexplicable by, or even opposed to, this theory; while of natural selection there seems to be absolutely no visible trace. The number of British forms which, at the commencement of the work, comprised 13 genera, and 454 partly invalid species, has now expanded to 74 genera, and 976 species, and varieties, to which even now accessions continue to be made.

In taking leave of his task, so worthily performed and to be continued by younger hands, the author, in spite of certain infirmities, does not relinquish his studies, but is now engaged on a Monograph of the recent species,[1] which it is to be hoped he may be spared to complete to his own satisfaction and the undoubted benefit of Science. W. H. Dall.

CORRESPONDENCE.

CORNISH SERPENTINE.

Sir,—I cannot reply fully to Mr. J. H. Collins's paper on the Cornish serpentine, published at page 298 of this Magazine, in which he repeats his mistakes as to the serpentine of Porthalla, until I have obtained permission from the Council of the Geological Society to have slices prepared for microsopic examination from the specimens which he presented in illustration of his paper published in vol. xl. of the Quarterly Journal. After this I think I shall be able to demonstrate that he has wrongly interpreted the very specimens on which his hypotheses are founded. In the mean time I will merely remark: (1) That the formation of the *mineral* called serpentine in the crevices of a rock no more proves that the *rock* serpentine is not of igneous origin than the occurrence of the mineral quartz in an adjacent vein proves that a quartz-felsite is not of igneous origin. (2) That (contrary to Mr. Collins's assertion) there is no essential distinction between the serpentine of Porthalla Cove and that from other parts of the Lizard district. There is as much difference as, but no more than may be commonly found between two dykes or two lava-flows in the same volcano. (3) That the serpentine of Porthalla in its relations to the hornblende-schist exhibits the usual indications of the intrusion of one rock to a plastic condition into another. The second and third of these statements will no doubt be put aside by Mr. Collins, like those of Mr. Somervail, as merely "a repetition of the dogmatic assertion." But in excuse for this dogmatism, I may remark that the question at issue between Mr. Collins on the one side and Mr. Somervail, myself, and those who have worked with me at the Lizard on the other, is really one of the observation of facts. He in effect says, "I cannot see any evidence of the intrusion of the serpentine into the hornblende schist." We reply, "To our eyes the junctions (with the usual indications) are often so plain that we doubt whether you really know for what to look." I may further plead in excuse of a little dogmatism on my own part that if there be one rock which I ought to know better than another it is serpentine (*i.e.* the rock of the Lizard type), of which I believe I have studied more examples and possess a larger collection than any other person in England; and if there be one class of phenomena with which I should be familiar, it is the junctions of rocks, whether brought about by igneous intrusion or by "the subsequent movements of the strata," subjects to which for the last ten years I have paid special attention. T. G. Bonney.

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[1] This Monograph is, we understand, shortly to be published by the Linnæan Society of London in its Transactions.—Edit.

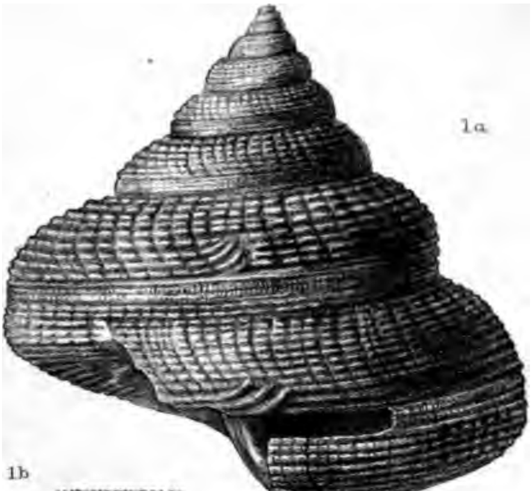
OBITUARY.

HENRY JOHNSON, F.G.S.,

BORN 1823; DIED 1885.

Mr. Henry Johnson, of Trindle Road, Dudley, civil and mining engineer, well known in the Midland Counties, and beyond, for his skill, energy, and successful appliance of knowledge and experience, has succumbed to a long infliction of sciatic rheumatism and ultimate prostration. Born in 1823, he was in his 63rd year when he died early in July last. Articled to a surveyor, he soon became successful in land and mining surveying, in railway work, and collieries. The great Sandwell Colliery, in particular, was re-established and extended by his labour and influence. The Watling-Street Colliery near Wilnecote, and the Peel Colliery, near Tamworth, with its extensive clay works, were won and established by him. He was also actively and successfully engaged with the South Staffordshire Mines' Drainage Scheme, and in the South Staffordshire and East Worcestershire Mining Institute. He contributed some good and useful papers to Societies with which he was connected,—as, for instance, that "On the Working of Thick Coal," to the Midland Institute, Birmingham, and "On the Geological Features of the South Staffordshire Coalfield," to the Iron and Steel Institute at Dudley, treating of the practical development of the Coal-field and improved working of the Mines. His services on Commissions, Trials, etc., connected with mining affairs, were highly valued and much sought after. He was ever ready to help his professional brethren, especially the younger engineers, with his counsel and practical aid. His talents as a draughtsman and in penmanship were appreciated from an early date. In a geological point of view Mr. Johnson had a ready and firm grasp on the bearings of geology on mining; and he particularly utilized his many opportunities, and gratified his natural taste, by collecting and preserving almost innumerable good specimens of fossils and minerals. The former he cherished with personal care and skilful manipulation, exhibiting their parts and characters clearly and with judgment, so that the palæontologist, visiting his wonderfully rich collection, not only saw specimens better than he had seen before, but always found a judicious selection of doubtful or unknown forms, of both animal and vegetable remains, which the energetic collector had saved and separated for examination by the specialist. As Mr. Johnson cheerfully exhibited whatever his visitors wished to see, so he gratefully accepted such information about his treasures as they were able to give. Not only his minerals and fossils, but his mining records and curiosities, are valuable memorials of his good taste, common sense, and acumen. He has left three sons and two daughters; and his long and fatal malady deprived him of the power of making such a provision for them as once he had a right to hope for.—T.R.J.

Professor H. Milne-Edwards.—It is with profound regret we have to record the death of one of the most eminent Naturalists of the present century, one too, who has witnessed its eventful history from its commencement. Born on 23rd October, 1800, he passed away in his 85th year, on the 29th July, 1885. Although *resident in* Paris, he was by origin an Englishman. We hope to give a suitable notice *of Prof. Milne-Edwards* in our next Number.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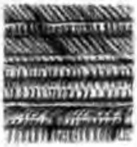
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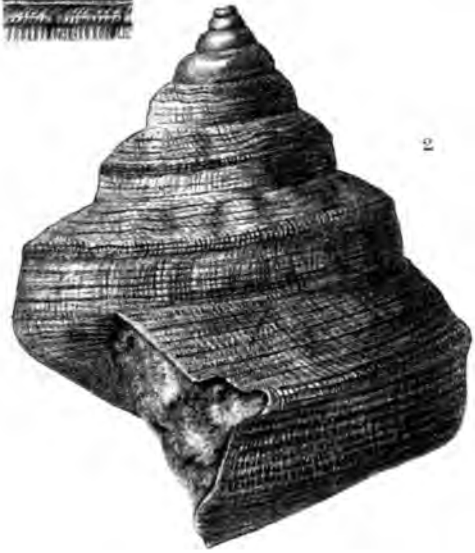
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Recent & Fossil Pleurotomariæ.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. II.

No. X.—OCTOBER, 1885.

ORIGINAL ARTICLES.

◆

I.—ON RECENT AND FOSSIL *PLEUROTOMARIÆ*.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

(PLATE XI.)

THE progress of modern discovery, both in Palæontology and Zoology, has been steadily tending to bridge over the gap which seemed at one time to separate the past from the present life-history of our globe, and has brought each more closely into relationship with the other than seemed possible fifty years ago.

Palæontologists are constantly discovering fossil forms to connect the past with the present, and zoologists, with equal zeal, are seeking new living ones to connect the present with the past.

The discovery of *Trigoniæ* in the seas, and the existence of *Ceratodus* in the rivers of Australia, offer us living analogues for a long series of ancestral forms, carrying us back through all the Secondary strata to the Trias, and in the case of *Ceratodus*, to the Coal-period; whilst the *Lingula* and the *Pearly Nautilus*, living to-day, have found remote ancestors in Silurian and Cambrian times.

The almost simultaneous discovery of remains of Scorpions in the Silurian rocks of America, Scotland, and Sweden, closely resembling those now living, attests the presence of dry-land and Insect-life in pre-Carboniferous times, and furnishes another link in the "Enchainements du Monde Animal," by which the long-buried past lives again by the light of the life of the present day.

A similar interest, zoologically and palæontologically, attaches to the ancient genus *Pleurotomaria*, a Gasteropod which, previous to 1855, was only known in a fossil state.

A large proportion of the older trochiform fossil shells have their whorls, whether round or angular, marked by a peculiar band, usually terminating in a deep slit at the aperture. Most of these were solid nacreous shells, and have been referred to the genus *Pleurotomaria*. Others are slender and tapering, and resemble a *Cerithium* with a notched aperture: they are named *Murchisonia*, and are probably related to *Pleurotomaria* proper.

In Woodward's "Manual of the Mollusca" the genus *Pleurotomaria* is said to range from the Silurian to the Chalk formation, and the number of species then recorded (in 1854) was 400. Since that date the number of fossil forms described has been greatly increased. The palæontological gap which seemed to separate the fossil *Pleuro-*

tomariæ from the fauna of to-day has been also reduced by the discovery of seven Eocene, two Miocene, and two Pleistocene species; whilst the dredge of the zoologist and the nets of the fishermen have demonstrated with equal success that *Pleurotomaria* is living in the seas of the present time.

The following is a list of the Tertiary species of *Pleurotomaria*:—

(EOCENE) *Pleurotomaria Bianconii*, d'Archiac, India.
———— *concava*, Deshayes. Paris Basin.
———— *Duboisii*, Mayer, the Crimea.
———— *Genyi*, Mayer, Nice.
———— *Kadin-Kewiensis*, d'Archiac, Asia Minor.
———— *Lamarckii*, Mayer, Switzerland.
———— *Nicæensis*, Bayan, Nice.
(MIOCENE) ———— *Sismondi*, Goldfuss, Bünde.
———— *tertiaria*, M'Coy, Australia.
(PLEISTOCENE) ———— *Fischeri*, Mayer MS., Guadaloupe ?
———— *Duchassaingii*, Schramm, Guadaloupe ?

The rarity of living *Pleurotomariæ*, whether in public Museums or in private Collections, is an incontestable fact. Neither the British Museum (Natural History), nor the Museum of the Jardin des Plantes, Paris, possesses an example.

Mr. W. H. Dall, in his Preliminary Report on the Mollusca dredged in the Gulf of Mexico, etc., 1877–78, by the U.S. Coast Survey Steamer "Blake,"[1] in 1881, records the existence of eight individuals only, that were actually known to him to exist in collections; whilst M. H. Crosse (Journal de Conchyliologie, 1882, p. 20), a year later, mentions ten specimens of living species obtained up to that date:—viz.:—1 *Pleurotomaria Rumphii* (in the collection of the Jardin Zoologique, Rotterdam); 5 of *P. Adansoniana* (viz. 1 in the collection of M. H. Crosse (the type), 1 in the Museum of M. Lherminier, 3 in the Museum of Zoology and Comparative Anatomy, Cambridge, Mass.); 3 of *P. Quoyana* (viz. 1 in the collection of Miss De Burgh (the type), 2 in the Museum Zool. and Comp. Anat., Cambridge, Mass.); 1 *P. Beyrichii* (collection of Dr. Hilgendorf). We may now add a second specimen of *P. Beyrichii*, in the collection of Mr. R. Damon, F.G.S., of Weymouth (see Plate XI. Fig. 1). This specimen, obtained by Dr. C. Gottsche, of Berlin, during his residence in Japan, from a fisherman of Enoshima, was actually caught with the mollusc in it, but the *intelligent* native very carefully removed it, and thus a most valuable prize was lost to science. Dr. Gottsche obtained the shell from the fisherman two hours after it had been taken alive, and from the good state of its preservation, and its brilliant coloration, there is every reason to believe that it was an actual living example when found.

It contrasts most favourably both in coloration and condition with Dr. Hilgendorf's specimen of *P. Beyrichii* (as figured by von Martens in the Conchological Mittheilungen, Cassel, vol. i. pl. vii. 1880), which does not display the slit, and is in an extremely poor state of conservation.[1] Indeed it seems very probable that it may have been, like the species first discovered (*P. Quoyana*), inhabited by a hermit-crab, at the time it was obtained.

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[1] Bulletins of the Museum of Comparative Zoology at Harvard College, vol. ix. Nos. 1-5, pp. 78-79, June—Dec. 1881.

In Mr. Damon's specimen the coloration is much more brilliant than is represented in von Martens' figure of Dr. Hilgendorf's specimen, and its altogether fresh and uninjured appearance suggests it to be the shell of a strong and healthy animal just caught alive. A small portion of the outer lip, on the lower side of the slit, has been broken away in removing the animal; otherwise the shell is quite perfect. The measurements recorded show Dr. Hilgendorf's specimen to be 8 mm. larger in diameter; its height is also 12 mm. greater than that of Mr. Damon's specimen.

[PLEUROTOMARIA BEYRICHII, Hilgendorf. (Pl. XI. Fig. 1, *a*, *b*.)

Pleurotomaria Beyrichii, Hilgendorf, 1877, Sitzungsber. Gesells. naturforsch. Freund. Berlin, p. 72.
——— ——— Schepman, 1879, Tydschr. d. Ned. Dierk. Vereen, vol. iv. p. 166.
——— ——— Crosse, 1880, Journ. Conchyl. vol. xxviii. p. 204.
——— ——— Martens, 1880, Conch. Mittheil. vol. i. heft 3, p. 33, taf. vii.
——— ——— Dall, 1881, Bull. Mus. Comp. Zool. Harvard Coll. vol. ix. p. 78.
——— ——— H. Crosse, 1882, Journ. Conchyl. vol. xxx. p. 16.

Animal and operculum of *P. Beyrichii* unknown.

Shell trochiform, solid, whorls nine, surface ornamented with numerous broadly spiral ridges, intersected by somewhat strongly-marked lines of growth, which follow the same wave-like, or V-shaped, curve, as the mouth of the shell. Aperture subquadrate, with a deep slit (about one inch) in its outer margin. The part of the slit which has been progressively filled up forms a distinct band round the whorls. There are 9 spiral ridges above the slit, and 6 below, in the body-whorl; but these lower ridges are overlapped in the upper whorls as far as the line once occupied by the slit, which forms a band around the whorls of the shell just above the suture. The lower margin of the whorls is bent at a rather sharp angle, the somewhat flattened base of the shell having 19 spiral ridges on it. The lip near the columellar margin is much thickened and flexuous, the interior of the shell and the umbilicus being nacreous. Colour pale-yellow, streaked with bright orange red.

Largest diameter of base of shell 75 millimètres; smallest diameter of base 65 mm.; total height 70 mm.; diameter of aperture 35 mm.; height of aperture 25 mm.; length of slit 22 mm.

Habitat:—Found living off the coast of Japan, at Enoshima, depth unknown.

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[1] Dr. C. Gottsche writes (Berlin, 22 July, 1885), "In Dr. Hilgendorf's specimen, which is a little rolled, and covered with Serpulæ and Bryozoa, the aperture is entirely broken away, so that the slit can only be reconstructed from the band." He adds that two more specimens of *P. Beyrichii* were brought back by Dr. Doederlein, of Strassburg in 1882, but they do not exhibit the slit itself. This statement brings the total number of living specimens of *Pleurotomaria* of all species known, up to 13 *individuals*.

Mr. W. H. Dall gives the following general description of *Pleurotomaria*:

"Shell trochoid in form, internally pearly, the last whorl perforated or fissured for the escape of eggs, or fecal matters, in the direction of the coil of the whorl.

"*Operculum* horny, subspiral or multispiral. Branchiæ two, nearly symmetrical, one on each side of the slit in the mantle corresponding to the fissure or perforations of the shell.

"Animal with papillose edge to the mantle and lateral fringes; without elongated cirri as in the Trochids; with no frontal veil, or fissuring of the foot. Muzzle simple, without a proboscis, eyes on pedicels exterior to the bases of the simple tentacles. Jaws small, weak." Then follows a description of the odontophore.

Mr. Dall adds: "A description of the soft parts of *Pl. Quoyana* and *Pl. Adansoniana*, with figures of the animal taken from life, is in preparation. It is to be regretted that the account will be rendered rather imperfect on account of the poor state in which the soft parts have come to hand. The more delicate portions were entirely destroyed. Those parts of importance in classification, being of a tougher nature, for the most part can be tolerably well made out. Sufficient is already known to show that the group possesses characters of family value, and stands nearest the *Trochidæ*, with features recalling *Haliotidæ*; and that it has nothing whatever in common with the *Pleurotomidæ*" (*op. cit.* p. 79).

Remarks on the other living *Pleurotomariæ*:—

Pl. Quoyana, Fischer and Bernhardi, 1856, was the first species of living *Pleurotomariæ* discovered. The type specimen (now in Miss De Burgh's cabinet) was figured in the Journal de Conchyliologie, 1856, vol. v. p. 165, pl. v. It is the smallest of living *Pleurotomariæ*, being only 35 millimètres in diameter, and 45 mm. in height.

The first specimen was obtained in a lobster-pot or trap sûnk in deep water off the island of Marie-Galante, and between that little island and Dominique (H. Crosse, *op. cit*, 1882, p. 15). It was occupied by a living hermit-crab.

Two other specimens were dredged *alive* off Barbadoes by the "Blake Expedition" under A. Agassiz, in 73 and 84 fathoms water (Mus. Comp. Anat. and Zool. Camb. Mass.).

Pl. Adansoniana, Crosse and Fischer (1861), is twice the size of *Pl. Quoyana*, and extremely like it in its neat and regular ornamentation; but the position of the slit-band, which is supramedian on the former, is median on the whorls of the latter species; whereas in *Pl. Beyrichii* it is inframedian in position. In both the West Indian species the coils of the shell are rather angular, and the slit-band is more prominent, and distinct.

(In *Pl. Beyrichii* the slit-band nearly coincides with the suture in all but the body-whorl, in which its position is seen to be much below the centre of the whorl. The whorls are more rounded than in the West Indian species, and the outline is therefore more graceful and elegant).

The specimens have been obtained as follows:—Islet of Fajou, Guadaloupe, in the great bay of Pointe-à-Pitre, in 150 fathoms; Barbadoes, 69 fathoms (dead); 94 and 200 fathoms (living) (see Journal de Conchyliologie, 1861, tome ix. p. 163, pl. v.; and 1882, vol. xxx. p. 12, pl. i.).

Pl. Rumphii is the largest of living *Pleurotomariæ*, being 190 millimètres in diameter, and 170 in height. M. Crosse considers it to approach most nearly to *Pl. Adansoniana*, but the height of *Pl. Rumphii* is double that of *Pl. Adansoniana* or of *Pl. Beyrichii*, and nearly four times that of *Pl. Quoyana.* It is, says M. Crosse, a veritable giant of the genus (op. cit. 1882, vol. xxx. p. 10). This interesting specimen is figured, from a photograph, by A. J. Wendel, and described by M. Schepman, in the Tijdschr. der Ned. Dierk. Vereen. Leiden, 1882, Deel VI. p. 23, pl. ii. figs. 1–3. Its habitat is said to be the Moluccas. M. Schepman discovered it among a number of shells from Molucca, in the Museum of the Zoological Gardens, Rotterdam, where the specimen is still preserved.

From the annexed table of species of *Pleurotomariidæ*, it will be seen that the 400 extinct species, known to Dr. S. P. Woodward in 1854, have now grown to nearly three times that number; whilst the gap which formerly existed between the Cretaceous and the recent forms is now bridged over by eleven species from the Tertiary and Quaternary deposits of various countries. Nevertheless one is reluctantly compelled to admit that, although not extinct, *Pleurotomaria* is a genus of the past, and that, numerically speaking, its sun has set, both as regards individuals and distinct species, when compared with the grand extension the genus enjoyed in Jurassic times, indeed from the Chalk formation to the Silurian epoch. [See Table, on p. 438. For the enumeration of the fossil species summarized in this table, I am indebted to my friend and colleague in the Geological Department, Mr. R. Etheridge, F.R.S.]

In quoting these figures as a census of species of *Pleurotomariæ*, it must always be borne in mind, that, as regards at least a large number of the Palæozoic species, although they have been referred to *Pleurotomariæ*, they may possibly belong to quite a distinct genus, as we are entirely unacquainted with the animal itself.

We give on Pl. XI. Fig. 2, a representation of a very well-known and beautiful form of *Pleurotomaria* (*Pl. reticulata*, Sby.) common to the Coral Rag of Weymouth and the Kimmeridge Clay of Wotton Bassett. This species is interesting as illustrating Dr. S. P. Woodward's observation on the genus ("Manual of the Mollusca," 1st edition, p. 147), that "specimens from Clay-strata retain their nacreous inner layers; those from the Chalk and Limestone have lost them, or they are replaced by crystalline spar."

It will be observed that *Pl. reticulata* attains a size almost, if not fully as large as *Pl. Beyrichii*, but the slit-band in this fossil species is *supramedian*, and *not* inframedian as in *Pl. Beyrichii.* The whorls in *Pl. reticulata* are rather more angular than in the Japanese species figured with it (Fig. 1); but the style of ornamentation has varied but little in this genus since Jurassic times.

In reference to the genus *Pleurotomaria*, Mr. W. H. Dall has the

Table of Distribution of the *PLEUROTOMARIIDÆ*.

		No. of species.	
Recent	West Indies ...	2	
	Moluccas	1	
	Japan	1	
			4 Living or Recent.
Pleistocene ...	West Indies ...	2	
			2 Pleistocene or Quaternary.
Pliocene	... ...	0	
			0 Pliocene.
Miocene	Germany	1	
	Australia	1	
			2 Miocene.
Eocene	France	3	
	Switzerland ...	1	
	Russia	1	
	Asia Minor ...	1	
	India	1	
			7 Eocene.
Cretaceous ...	Switzerland ...	136	
	France	37	
	India	2	
	America	2	
	England	31	
			208 Cretaceous.
Jurassic	Germany	45	
	France	198	
	Russia	3	
	England	121	
			367 Jurassic.
Permian	Germany	8	
	Russia	1	
	England	3	
			12 Permian.
Carboniferous	America	65	
	Belgium	130	
	Russia	10	
	England	53	
			258 Carboniferous.
Devonian ...	America	31	
	Rhenish Prussia	72	
	Russia	8	
	France	3	
	England	9	
			123 Devonian.
Silurian	America	113	
	Gotland	41	
	Russia	9	
	Bohemia	3	
	Australia, etc. ...	2	
	England	9	
			177 Silurian.
			1160.

Summary—

Living species ...	4
Tertiary	11
Secondary	575
Palæozoic	570
	1160.

British fossil species of *Pleurotomariæ* ... 226.

following remark (Bulletin of Museum of Comparative Zoology, Cambridge, Mass., 1881, vol. ix. p. 78): "It seems to have been overlooked until now, that we are indebted to Sowerby for its characterization, and that he is entitled to be cited as authority for the genus." But on referring to James de Carle Sowerby's description of the genus *Pleurotomaria*,[1] Min. Conch. vol. vii. p. 69, pl. 640 (published November, 1844), he cites Defrance as his authority.

It is true that in Defrance's "Tableau des Corps Organisés Fossiles" (8vo. Paris, 1824), he merely gives the name (p. 114); but in the "Dictionnaire des Sciences Naturelles" (vol. xli. 1826, p. 381), De Blainville adopts Defrance's name, and credits him with most of the new species described. It is also perfectly true that Sowerby defined the genus, but to assume that he founded it would be unjust to Defrance, especially since both De Blainville and Sowerby have given Defrance credit for the genus. If such a rule, as is thus proposed by Mr. W. H. Dall, were generally adopted by naturalists, endless confusion would arise and great injustice would be done to all the older naturalists whose work laid the foundation for the researches of the generation of younger men who have followed after.

EXPLANATION OF PLATE XI.

Fig. 1*a*. *Pleurotomaria Beyrichii*, Hilgendorf. Recent. Enoshima, Japan. (Nat. size.)
,, 1*b*. Portion of the slit-band (enlarged).
,, 2 *Pleurotomaria reticulata*, Sby. (nat. size). Kimmeridge Clay, Wotton-Basset. The nacreous inner layer of the shell is well preserved.
Fig. 1 is from the cabinet of Mr. R. Damon, F.G.S., of Weymouth.
Fig. 2 is preserved in the British Museum (Natural History).

Note.—Mr. Robert Damon has kindly given me permission to retain his specimen of *Pleurotomaria Beyrichii* on exhibition for two months in the table-case with the fossil *Pleurotomariæ* in Gallery B, Department of Geology.—H.W.

II.—On Bastite-Serpentine and Troktolite in Aberdeenshire, with a Note on the Rock of the Black Dog.

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., Pres.G.S.

In a paper entitled "On Minerals new to Britain,"[2] published in the Mineralogical Magazine, vol. v. p. 1, Professor Heddle mentions the occurrence of a bastite-serpentine at two localities in Aberdeenshire; one in the parish of Belhelvie, the other on the shore close to a curious rock named the Black Dog. A visit to the localities has enabled me to add to his account some particulars, and to offer one or two corrections which seem to me not unimportant.

Professor Heddle states that he found the rock in the former case "in two quarries which are cut into a hill-side near the farms of Craigie and White-Cairns, on the west side of the Belhelvie hills."

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[1] Sowerby's description is as follows:—"Pleurotomaria, *Defrance*. Gen. char. A trochiform spiral shell, with an angular sinus near the middle of the outer lip, from which a band marked with lines of growth that indicate the sinus is carried round the whorls; no beak or sinus at the base of the aperture; a columella with or without an umbilicus."—(Sowerby, Min. Conch.)

[2] In this paper the term mineral is used in a very wide sense, as it includes *tachylyte*, *Lydian-stone*, *chert*, *lignite*, *spherulite*, and *pitchstone*. If all of these are minerals, what are left to us as rocks?

I believe that I visited the same locality, though I could only find one quarry in serpentine (very probably two excavations have now been worked into one). The locality is about eight miles from the town of Aberdeen, and a short distance to the east of the high road to Tarves.[1] The quarry is close to a branch road and is visible from the main one. I was told that the name of a farmhouse, which stands on the ridge, a short distance north of the quarry, is Overhill. This ridge is a conspicuous feature, running for a considerable distance roughly parallel to the road, as the above-mentioned quarry is approached. It is no doubt a portion of the "ridge of dark trap," which is mentioned in the Ordnance Gazetteer of Scotland as "starting from the Black Dog's mouth, and running through the entire parish of Belhelvie, from four to six furlongs wide, . . . flanked at one point by serpentine."

The outcrop of serpentine is but a small one, for it does not appear to extend much beyond the limits of the pit. The ridge here, and doubtless elsewhere, mainly consists of a rock of rather variable coarseness, which much resembles the well-known troktolite (or forellenstein), of Volpersdorf. This similarity struck me at once in the field, and is fully borne out by microscopic examination. My remarks will be chiefly directed to the structure of these two rocks and their relations.

The matrix of the serpentine is compact, of a dark brownish to greenish black colour, speckled by very minute crystals or granules of a mineral resembling one of the spinellid group. There are irregular patches, two inches or more in greatest diameter, of a greenish-white, steatite-like mineral full of small rounded inclusions of the dark matrix; so as to form a kind of rude network or cell-like structure. Closely associated with this are crystalline grains of bastite (with the usual rounded inclusions of the matrix), at most about one half of an inch in diameter, and of rather feeble lustre. From the general appearance and relation of these two minerals, one would conclude that the white mineral was the result of a further change of that represented by the bastite. The rock in its general aspect, jointing, fracture, and mode of weathering, corresponds with a true serpentine, such as that of the Lizard. It very closely resembles my hand-specimens of bastite-serpentine from Baste (Hartz), Kupferberg (Bavaria), and Sta. Catarina (Elba). Of the first and third I possess slides, which prove the rocks to be almost identical.

The Belhelvie serpentine (rock) consists of the following minerals: (1) *Olivine*, more or less converted into varieties of the mineral serpentine, with separation of the iron in the form of magnetite, etc. I have so often described the gradual formation of the "strings" of greenish and rather fibrous serpentine along the cracks of the original olivine, and the way in which they, and sometimes the mineral occupying the interstices between them, are discoloured by the deposit of magnetite, hæmatite, etc., that it is needless to occupy any space by repeating the usual details. Portions of unaltered olivine still remain in fair number between the serpentinous strings, which in several cases are shown to be remnants of one crystal, by identity of colour when placed between crossing Nicols. (2) *Bastite, etc.*, viz. enstatite in various stages of alteration. This mineral, as is common, includes some olivine grains like an irregular setting, and therefore must belong to a later epoch of consolidation. We find it in various stages, from a characteristic enstatite, not very much altered, to a kind of steatite speckled with earthy-looking granules, and so rendered occasionally almost opaque. Sometimes the steatitic product is isotropic, at others it appears as an aggregate of very minute moderately bright-coloured granules. (3) Besides these, the slide exhibits a fair number of grains, not very regular in outline, either opaque or very dark brown in colour, most likely representatives of the spinellid group, and in part probably chromite.[1]

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[1] It is marked on Dr. A. Geikie's Geol. Map of Scotland.

Thus the serpentine has been derived from an olivine-enstatite rock, such as would be called a *Saxonite* by Dr. Wadsworth.

The serpentine has been worked back to its junction with the troktolite, which constitutes the main mass of the ridge. This is usually a moderately coarse-grained mixture of purplish-grey or whitish felspar and dull dark-green serpentine. Coarser varieties occasionally occur; usually the felspar is to the serpentine in about the proportion of three to two, but occasionally a fragment is seen in which the former mineral distinctly predominates. A pyroxenic constituent, if present, is very inconspicuous. The rock is boldly but rather irregularly jointed and weathers with a brown rough surface.

I have examined a series of slides representing the average rock of this part of the ridge, the coarser kind, and varieties respectively rich in felspar and in serpentine. In the normal rock the felspar is fairly well preserved, though rather cracked, probably by molecular strains due to the alteration of the olivine constituent. It exhibits the usual twinning of plagioclase, the groups of macles being combined in both the Carlsbad and perikline types, and the large extinction angles show that anorthite is present. The olivine has been almost wholly converted into an olive-green to greenish-brown serpentine with the usual structure; only rarely does a fragment of the original mineral remain unaltered. There is a certain amount of diallage, more than one would have expected from a macroscopic examination of the rock. This occurs in rather small irregular "interstitial" looking grains, and now and then includes or is pierced by a small crystal of the felspar, having been the last to consolidate. There are also a few grains of iron oxide. One slide is traversed by a vein of chrysotile. In the coarser varieties the felspar is not quite as well preserved, but a fair amount of olivine is still unaltered, the two minerals being more nearly in equal proportions. In this there is little or none of a pyroxenic constituent.

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[1] Plate viii. figs. 2 and 3 (one of the peridotite of the Hartz, the other of that from Christiania) in Dr. Wadsworth's Lithological Studies, part i. would very fairly illustrate the serpentine described in this paper.

I possess a slide of the Volpersdorf troktolite, and have to thank Prof. Judd for the loan of others, as well as of a slide of the same rock from Baste. All these agree very closely with the rock described above. In them also, diallage is sparingly present in narrow irregular-shaped grains, so as not readily to catch the eye in hand-specimens (one, however, of my specimens of Volpersdorf rock has two or three conspicuous crystals of diallage). Hence we need not hesitate to call the Belhelvie rock a troktolite or forellenstein.

In my paper on the Serpentine of the Lizard (Quart. Journ. Geol. Soc. vol. xxxiii. p. 906), I describe a rock from Coverack Cove, as being almost identical with the forellenstein of Volpersdorf, and this was afterwards confirmed by an analysis by Mr. F. T. Houghton (Geol. Mag. Dec. II. Vol. VI. p. 504).[1] The Coverack troktolite, however, has probably a little more diallage than the Volpersdorf rock, and in the specimen analyzed there was only 33 per cent. of olivine as against 45 per cent. in the latter rock. Macroscopically and microscopically, this Belhelvie troktolite looks even nearer the Volpersdorf type than that of Coverack Cove. A chemical analysis, however, for which I am indebted to the kindness of A. E. Brown, Esq., B.Sc., of University College, London, shows that on the whole the Belhelvie rock is more closely allied to the troktolite of Coverack than to that of Volpersdorf, and the per-centage of Al_2O_3 is rather larger, and that of MgO rather smaller, than my estimate founded on microscopic examination led me to expect. The following is the analysis (S.G. = 2·73).

H_2O	8·12
SiO_2	39·87
Al_2O_3	24·30
Fe_2O_3	1·59
FeO	4·09
CaO	7·61
MgO	11·30
*K_2O	1·11
*Na_2O	1·93
	99·92

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[1] I append the analyses made or quoted by Mr. Houghton. I. is the Volpersdorf rock, II. that of Coverack, III. the felspar of No. I., IV. the felspar of No. II. From the latter two it is evident the Coverack rock contains rather more labradorite than the Volpersdorf rock. I think, however, that the specimen analysed of the latter rock must have been a little richer than common in olivine.

	I.	II.	III.	IV.
H_2O	8·30	4·38	1·87	3·19
SiO_2	41·13	45·73	47·05	49·65
Al_2O_3	13·56	22·10	30·44	29·34
Fe_2O_3	2·19	0·71	1·56	0·59
FeO	6·19	3·51		
CaO	6·72	9·26	16·53	12·18
MgO	22·52	11·46	0·09	0·46
K_2O	0·83	0·34	0·78	0·48
Na_2O	0·96	2·54	2·10	3·61
	102·40	100·03	100·42	99·51

* Mr. Brown adds, "The values of these are uncertain—the numbers given are the means of two experiments: the limits between which the value may lie are Na_2O 1·85 to 2·33, K_2O 1·19 to ·71.—Total 3·04."

I may call attention to another point of resemblance between the ornish and Belhelvie rocks in their relation to the serpentine. At overack Cove the serpentine is the oldest rock; it is cut by the 'oktolite, and both are cut by an ordinary coarse olivine-gabbro. 'ow the serpentine and troktolite are so closely united that at the rst glance we might suppose the one passed into the other. This, owever, is certainly not the case, but the junction is so perfect that ey appear, as it were, fused together; while at the junction of the livine-gabbro and the serpentine there is commonly a line of division r a crack, which is enlarged by weathering. It would be interestg to see whether in the Belhelvie ridge there were any indications f a normal gabbro and what was its relation to the other rocks. 'rofessor Judd has also observed the complete sequence of serpentine or peridotite), troktolite, and olivine-gabbro in the western isles f Scotland. For the last rock to cut serpentine is common.

One point remains for consideration. What is the relation of the oktolite to the bastite-serpentine? Do they form part of one nd the same eruption, or is the one distinctly subsequent to the ther? The difference between the two rocks, notwithstanding the apid variation which is often exhibited by peridotic rocks, seems oo great to render the former hypothesis very probable; further, by areful search I discovered in one part of the pit a fairly sharp unction between the serpentine with bastite and the troktolite, of which I succeeded in securing specimens. I noticed, however, that n one place the troktolite, probably at a distance of three or four feet rom this apparent line of demarcation, changed in the course of bout three inches from a variety in which the felspar distinctly revailed over the olivine to one in which there was more olivine han felspar, perhaps twice as much. In the latter the felspar is lmost wholly replaced by secondary products. The greater part f the replacing substance is a minutely granular to slightly fibrous naterial, which with crossed Nicols changes, as the slide is rotated, rom dark to a pale milky or greyish white; in it are scattered few granules giving rather bright colours. Much of this might eadily be taken for a steatitic mineral, but on testing the spots at he surface of the rock with a knife the hardness appears to be early that of felspar. I have examined a slice cut to exhibit the bove-mentioned junction. It is rather less than an inch long; about in. being troktolite, the remainder serpentine. The former (except or the presence of a peculiar structure to be noted presently) is normal troktolite, with the plagioclase felspar quite distinct, hough much cracked; the latter, consisting mainly of altered olivine, xhibits among this mineral two or three irregular interspaces ccupied by a clear substance, which with transmitted light does not iffer much from the felspathic portion of the troktolite, but which vith crossed Nicols remains wholly, or almost wholly, dark in every osition, and is probably steatite. This can be scratched easily with he knife-point, while the colourless mineral of the troktolite is not asily so marked. At the same time the slide does not exhibit the harp demarcation commonly seen when one igneous rock has intruded into another, but the boundary is irregular, the felspathic portion of the troktolite seeming to pierce or send off-shoots into the serpentine. This debateable region may be about one-eighth of an inch wide. As in addition each rock in the slide is about of its normal coarseness, I should conjecture that the intrusion took place when the older rock was at a high temperature, and perhaps was still plastic. Which, then, was the earlier? At Coverack, in the instances on the West Coast of Scotland described by Prof. Judd, and in several cases where I have examined the junctions of ordinary gabbros and peridotic serpentines, the felspathic rock is the later of the two; though I may add that its coarse crystallization seems to indicate that its cooling was very gradual. In this case it is more difficult to come to a conclusion. The felspar of the troktolite near to the junction appears to occur in slightly smaller grains than in the normal rock, but the difference is slight and the rock variable. There is, however, one peculiarity. Near to the junction every grain of olivine is surrounded by a fringe-like border, resembling an incipient spherulitic structure. In some cases this appears double, the zone nearest the olivine consisting possibly of a serpentinous mineral; but the outer, and in some cases the only mineral occurring, is a long and somewhat fibrous microlith, which from its general aspect and extinction-angle I should judge to be actinolite or tremolite.[1] In these slides the flakes or border of diallage noticed in the normal rock are wanting. It is possible that the structure might be a result of the intrusion of the serpentine into the troktolite; but on the whole I incline to the opinion—though not without hesitation—that the former rock is the earlier.

The Black Dog is a mass of rock about four yards long and broad, and rather more than two high, which projects from the sand and bears a very rude resemblance to the creature from which it is named. A dozen or more of much smaller blocks are scattered about in the neighbourhood, some a little nearer to, some a little further from the land. Most, if not all, of these can be visited at low water. Rain and wind prevented me from attempting to plot down these blocks (whether they are *in situ* or boulders I cannot say), and obliged me to content myself with a rather hasty examination of them. Professor Heddle speaks of two masses of serpentine, a little seaward of the Black Dog. I obtained my specimens from two masses rather on the landward side (and to north of it), and there was a third not far from these, but I noticed two or three more dark blocks surrounded by the sea, which may have been those spoken of by Professor Heddle. Of the remaining blocks, one was certainly a dark gneiss; the others appeared to me to resemble the rock of the Black Dog, but at these I barely glanced.[2] Macroscopically the only difference between this serpentine and that of Belhelvie is that in the former there are much larger masses of the bastite and much less of its steatitic alteration products. Under the microscope the differences are but varietal.—rather less olivine remains unchanged, and the slides have a rather greener hue; this colour here and there occurring rather markedly in little filmy patches, as if a small amount of a chloritic mineral were present.

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[1] These or other microliths sometimes pierce the felspathic part of the slide in a way that recalls the canal system of Eozoon, but to discuss this would require too long a digression for the present occasion.

[2] Boulders are not common on this part of the shore. In fact, I do not remember observing one for about a mile and a half to the south, so that the rock probably is either *in situ* or has come from the immediate neighbourhood.

Professor Heddle gives an analysis of this bastite, freed as far as possible "from the dark serpentinous rods which penetrate the mineral in so singular a manner" (these of course are the included grains of serpentinized olivine).

By the side of it (I.) I place for comparison an analysis (II.) of the bastite from Baste[1] (Köhler, quoted by Dana, Mineralogy, p. 469):

	I.	II.
SiO_2	38·186	43·90
Al_2O_3	2·178	1·50
Cr_2O_3	·276	2·37
Fe_2O_3	·028	...
FeO	8·479	10·78
MnO	·513	·55
CaO	2·912	2·70
MgO	31·418	26·00
K_2O	1·401	·47
Na_2O	.065	
H_2O	14·030	12·42
	100·486	100·69

Enstatite, more or less altered, is common in British serpentines, but this is the first instance I have seen of the varietal form bastite, —if we restrict this name to the large grains with inclusions of more or less altered olivine.

I pass on now to the rock of the Black Dog. This, according to Professor Heddle, "consists of crystals of *talc*, matted in such confusion as to form both a tough and a hard rock." As talc is about the lowest mineral in the scale of hardness, and its allies steatite, agalmatolite, etc., are all rather soft; and as minerals do not generally change their physical characteristics, however confusedly they may be matted, I looked forward to the examination of the Black Dog with much interest. Wet as it was with waves and rain, I could only see that it was a mottled dull-green to black rock, sparsely speckled with small scales of a silvery mica, and not unlike the troktolite; when dry, however, it appeared slightly foliated in structure. Smoothed by the action of the waves it presented but few prominences. Selecting one of the least unhopeful I endeavoured to detach a specimen. A very few minutes sufficed to show the impossibility of any form of talc being the dominant mineral. I plied vigorously a fairly heavy hammer for about five minutes, first at one place, then at another hard by it, with only this result:—that I detached one chip about as large and as thick as a florin and a number of tiny splinters. The latter had set their mark effectually on my right hand in the form of three cuts, one pretty deep. At last, after one or two more unsuccessful attempts, I secured a moderate-sized fragment of a rock which I may fairly describe as one of the hardest and toughest that I have ever assailed. It needed but a glance to show that the rock was highly crystalline, and quartzose, without any mineral that could possibly be compared with talc, except the not very abundant silvery mica. I believe there is only one Black Dog, or I should have supposed, so obviously incorrect is Prof. Heddle's statement, that he were speaking of some other rock.

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[1] Comparison of these renders it highly probable that II. was more completely freed from the olivine grains than I.

The rock on a smoothed surface has a dull grey or bluish-grey colour, mottled or rather streaked in an irregular fibrous manner with a darker, almost green-black tint, and spangled with a few small flakes of a silvery mica. A broken surface exhibits a more or less crystalline structure, with an irregular fracture, as if the component minerals were tough and had been torn asunder rather than snapped. On these surfaces the grey assumes a rather more distinctly violet-blue tint. The outer part and the surfaces of fissures are stained brown. The slides, viewed with reflected light, in certain positions also exhibit in parts a slightly bluish hue. This is very faint, but I think indubitable, and much resembles the peculiar violet-blue of some varieties of cordierite (iolite).

On examining the slide with a one-inch objective, by transmitted light, we see a number of wavy, more or less translucent subparallel streaks, varying in colour from dull light-brown to dusky grey, which have a fibrous aspect and evidently consist of fine aggregated hair-like minerals which stick out in the streaks in various directions, though on the whole they maintain the same general orientation. We may in fact compare the streaks to rather matted locks of hair. Between these is a mineral generally clear, but sometimes a little dirty-looking, which occasionally exhibits a granular structure; among both these a number of black grains, sometimes more or less rounded, sometimes angular, are scattered rather irregularly. Here and there we observe a mineral resembling a white mica in detached crystals, with irregular patches of a rather gummy-looking yellowish-brown mineral, and some small crystals of a brown mica.

After a careful examination of the hair-like mineral with high powers, I have come to the conclusion that in all probability the greyer and the browner patches are alike aggregates of the acicular microliths which project from the edge, but possibly the latter may be darkened in colour by the inclusion of some exceedingly minute ferrite (though even with a one-eighth objective I can make out nothing definite beyond the crowded microliths); and that we may safely regard this mineral, so abundant in the slide, as a variety of fibrolite. It is almost exactly like that in the cordierite-gneiss of Bodenmais, which, however, sometimes has the microliths of larger size, resembling those in a typical specimen of fibrolite from the same locality, which I have in my collection.

Among the colourless minerals I notice that a fair proportion have one well-defined cleavage, while of the remainder, some present only faint indications of it, or indicate no more than a tendency in a parallelism of included microliths, while others show no sign at all. Among the first, some are certainly the white mica, the larger grains of which are visible to the unaided eye. These give bright colours with crossed Nicols, extinguish parallel with the cleavage planes, and have a rather spangled or satiny aspect, even at the moment of extinction. In a word this mineral reminds me in its general aspect of a hydrous mica, and is not unlike paragonite. But there is another well-cleaved mineral, which, though showing bright colours and well cleaved, gives more uniform tints, and I think more frequently contains inclosures of fibrolite than the mica. I suspect this to be kyanite. Of the remaining clear grains, including some without visible cleavage, the extinction, where cleavage planes are visible, is parallel with them. The colours, though they have a general resemblance to those of quartz, are rather more intense than is usual with it. The mineral also is not quite so clear and glass-like, and not seldom gives indications of incipient decomposition. This I consider to be very probably iolite. Other grains, however, are certainly quartz. The black granules are an iron oxide, and are probably in great part hæmatite. As pyrrhotite is present at Bodenmais, I have looked carefully for this mineral, but cannot detect it. The yellow-brown mineral occurs in irregular filmy patches and exhibits no definite structure. With crossed Nicols, it either remains dark, or gives very faint indications of an aggregate structure. Some, I feel sure, is a staining of hæmatite or limonite. This also occurs in some of the Bodenmais rock. The brown mica calls for no special remark.

A few other microlithic minerals are present which I am not able to identify with precision. In one slide, however, I find a single instance of a peculiar mineral. It is a patch of irregular outline, (including several of the black grains, with little if any fibrolite), in diameter about ·07 inch, with one or two small outliers—cleavage very dubious, possibly indications of two meeting at angles not very far from 90°—pale puce-grey or dove-coloured by ordinary transmitted light—strongly dichroic—extinction seemingly parallel with the best indicated cleavage, which corresponds with a slightly fibrous appearance,—dull olive-green for vibrations perpendicular to this; light dove-coloured or puce-brown for parallel vibrations. The general look is like that of a mica in which the usual basal cleavage is not distinctly shown, as is the case with some of the brown mica in the slide.

As the fibrolite appears to be present not only in the altered iolite, but in the quartz and in these streaky masses, it is probably of independent origin.

We may then, I think, confidently affirm that this Black Dog rock principally consists of fibrolite (sillimanite), iolite more or less altered, quartz, and some micas.

The above described slides present considerable resemblances to some from the cordierite-gneiss of Bavaria. Some of the latter contain very conspicuous cordierite, but others almost exactly resemble the Black Dog rock, and these abound in the minute, thickly aggregated fibrolite. There is a generally similar association of minerals in the cordierite-gneiss of Galgenberg. I am greatly indebted to Professor Judd for the loan of additional slides of the Black Dog rock, made from my specimens, and for a series of slides of cordierite rock from the above-named localities, and from Burgstadt (near Chemnitz), Penig, Orijesvi (Finland), and Sertudalen (Sweden).

About half-way between the Black Dog rock and the mouth of the Don,—and so about half a league N. of the latter, sundry blocks of a dark rock are strewn on the shore, some of considerable size. One is apparently a dark gneiss, others are evidently an igneous rock. I collected two varieties, one representing the two largest blocks which lie close together, as though they had once formed a single mass. It is a heavy dark green rock speckled with grains of a lighter colour, weathering brown. The following is a description:—holocrystalline, structure intermediate between granitoid and ophitic, consists mainly of labradorite, augite and some olivine. The labradorite is well preserved, exhibiting the usual lamellar twinning and very bright colours with the crossed Nichols; the augite, or rather diallage, for the pinacoidal cleavage is generally well developed at the expense of the prismatic, is light brown-coloured in many of the grains, and exhibits the "schillerization" to which Prof. Judd has lately drawn attention; the olivine (not abundant) has its cracks bordered with a staining of opacite; some parts are converted into a dull brownish-green serpentine, but others are very well preserved. A few larger granules of black iron oxide occur in the slide. Another specimen of a finer-grained rock contains no olivine, but a little brown mica; the pyroxenic mineral also is partly diallage, partly a mineral of the hypersthene group, probably allied to the variety called amblystegite; it is distinguished by a more marked dichroism, altering from a pale greenish to a bluish hue, and extinguishes parallel with the pinacoidal cleavage. The mode of occurrence of the two minerals, which are not always easy to distinguish, is very similar, and they appear to have consolidated as nearly as possible simultaneously. There is also some apatite in the slide, and as usual some grains of iron oxide.

III.—ON THE ORGANIZATION AND ECONOMY OF THE GRAPTOLITHIDÆ.

By Dr. OTTO HERRMANN.[1]

IN the first place, let us obtain a clear idea of a Graptolite, and for this purpose we will consider two members of the family Dichograptidæ, namely, *Didymograptus vacillans*, Tullb. (Fig. 2, p. 452), and *Dichograptus octobrachiatus*, Hall (Fig. 1, p. 449).

The entire polypidom (Hydrosoma, polypary, Frond, "polypier," "polypariet") proceeds from a simple, hollow cone (sicula, "Fuss," "Haftorgan," Radicle or initial point *ex parte*), which, in the compressed state, presents itself as a pointed, dagger-shaped organ (Fig. 2 *s.*). In its external wall a bacilliform axis (virgula, solid axis "axe solide") is developed, and two embryonal buds soon begin to sprout forth from the sicula, become converted into cells (Hydrothecæ, "Zähne," denticles, calycles, "cellules," "Thekorna"), and form the commencements of two branches ("Arme," "Zweige," stipes, branches, "Grenarne") diverging at a definite angle. Each of these branches represents a tube, the cavity of which ("Gemeinsamer Canal," common canal, "Canal commun") is occupied by the soft animal proper (cœnosarc). The axis lies upon the dorsal surface of the branch; opposite to it are the hydrothecæ arranged in consecutive order (Monoprionidian Graptolites). The walls of the canal in the living state were chitinous ("Skeletbildende Substanz," "Haut," "Schale," periderm, perisarc, test), and consist of three laminæ. In most cases the branches in growing did not continue simple, but forked; the forks thus formed might divide again, etc. By two such divisions an eight-branched form is produced (*Dichograptus octobrachiatus*, Hall, Fig. 1). It has been thought that the basal parts of the branches in many ramified Graptolites were free from hydrothecæ, and this "naked" part has been named the stem ("Stiel," funiculus, funicle). In some species these basal parts of the branches are united by a chitinous membrane (Discus, central disc, corneous disc, Fig. 1).

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[1] The second chapter of Dr. Otto Herrmann's memoir on the Dichograptidæ, the first chapter of which appeared in this MAGAZINE for September, 1885. Translated from the Nyt Magazin for Naturvidenskaberne, vol. xxix. pp. 160-176.

In what follows we shall chiefly employ the nomenclature established by Allman and others for the different parts of a Hydroid Polyp.

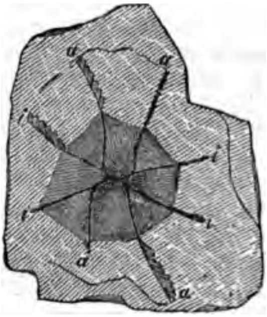

FIG. 1. *Dichograptus octobrachiatus*, Hall, from the *Phyllograptus-shales*, Galgenberg, Christiania. Natural size. Original.

THE SICULA.—The inconspicuous organ to which Lapworth has given the name of the *Sicula*, and which early attracted the attention of palæontologists, but under the names of "Haftorgan," "radicle," etc., has received a false interpretation, has now, since the recognition of its true significance, and of the part it plays in the development of the polypidom, taken a prominent position among the organs of the animal-colony. If we have to decide whether fragments of Graptolites that may be met with belong to the single-branched family Monograptidæ, Lapw., or are fragments of branched Graptolites, this cannot be done until the discovery, upon one of the fragments, of this organ, the presence of which proves the completeness of the proximal extremity, or until we find two such branches held together by this dagger-shaped organ; in the former case we have to do with a species of the Monograptidæ; in the second with a species of one of those families which include two-branched forms.

The sicula has another significance as a classificatory element. It has been shown that the further development of the hydrosoma, which is commenced by the sprouting of the primordial buds, does not always proceed from exactly the same spot in the sicula, but that, in certain groups, which may even show agreement in their other characters, it commences at different points of the margins of the sicula. In the fixing of the angle of divergence between the branches of the ramified Graptolites, the sicula also plays an important part.

The conditions here indicated involve a number of questions which we find answered in different senses by different authors, and some of which have been the subjects of lively controversy, without any accordant and satisfactory answer being arrived at. It therefore appears to me worth while to examine some of these unsettled questions in detail, and to show what views in my opinion deserve the most consideration.

In the first place we must glance briefly at the question whether the Graptolites were attached by the sicula to the sea-bottom or to some foreign object. Hall, who figured Graptolites with the sicula as long ago as 1847, in 1865, in his great work,[1] expressed the opinion that some species, and especially those of the family Dichograptidæ, Lapw., in the early period of their growth, were seated temporarily upon the sea-bottom or upon foreign objects. Richter, who, in 1850, figured the sicula in Thuringian forms, characterizes the organ as the "foot" (Fuss) or "adherent organ" (Haftorgan), names which of themselves involve the conception of its function. Scharenberg,[2] in 1851, writes that in many species this appendage indicates a tolerably firm adhesion, but in others only a loose insertion into the muddy sea-bottom. Geinitz, in 1852,[3] says that the genera *Diplograptus* and *Didymograptus* (*Cladograptus*) had "their lower extremity plunged into the sand or mud." Nicholson (1872)[4] believes that the "radicle" in some forms of the genus *Didymograptus*, M'Coy, served as an adherent organ, but that other genera, such as *Monograptus*, Gein., and *Cœnograptus*, Hall, were not attached by that organ.

More recently an opinion has made much way that all Graptolites provided with a sicula inhabited the sea as non-attached organisms, and that the discovery of the sicula on imperfectly known forms of the true Graptolites or Graptolite-like organisms will furnish a proof of their former free mode of life.

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[1] Figures and Descriptions of Canadian Organic Remains, Dec. ii., Graptolites of the Quebec Group, Montreal, 1865.

[2] Ueber Graptolithen, etc., Breslau, 1851.

[3] Die Versteinerungen der Grauwackenformation in Sachsen: I. Graptolithen, p. 17.

[4] *Monograph of the British Graptolitidæ*, p. 63.

In many genera (*Didymograptus*, *Dicellograptus*, *Cœnograptus*, etc.) the sicula runs out into a point as sharp as a hair; in other forms (*e.g. Dichograptus octobrachiatus*, Hall, Galgenberg, Christiania) it has acquired the form of a round knot or knob; in other species again (*e.g.* species of *Tetragraptus*) it entirely disappears in full-grown individuals, although the spot at which we ought to look for it is quite uninjured. All this speaks against a former attachment.

We now assume that all Graptolites provided with a sicula were not attached bodies.

It is indeed conceivable that we have an analogy with existing Cœlenterata, in which also attached forms (these would correspond to the arborescent Graptolitiform organisms) are known, as well as forms which are inserted into the mud, and perfectly free. But whether they pierced into the mud of the sea-bottom with the sicula, or whether the Graptolites kept at small depths like a Cartesian diver in a vessel of water, will depend upon how far down in the deep seas of that time, the element of the Graptolites, organic existence was possible.

ANGLE OF DIVERGENCE.—Before we advance to the definition of the angle of divergence in the branched Graptolites, we must make out clearly what part of the hydrosoma we are to regard as the sicula in the different groups of Graptolites, seeing that the sicula and angle of divergence stand in the closest relation to each other.

In most genera, as, for example, *Didymograptus*, M'Coy, *Dicranograptus*, Hall, *Diplograptus*, M'Coy, and *Monograptus*, Gein., there is no doubt about this, but not so in the genus *Dicellograptus*, Hopk. The situation of the sicula here has been a question in dispute, and indeed because in that genus there are often four processes at the point where the two branches grow together, one of them situated on the dorsal side of the branches, and three upon the cell-bearing ventral side (Fig. 3). Hopkinson, who in 1871[1] separated the genus *Dicellograptus* from the *Didymograpti*, considers the middle one of the three spines which are placed side by side to be the sicula ("radicle"), and defended his idea warmly against Nicholson, who,[2] in some of the forms now referred to *Dicellograptus* (*e.g. D. anceps*, Nich.), regarded the process on the dorsal side of the branches (Hopkinson's "axillary spine") as the embryonal piece. Nicholson, himself, however, is not consistent in his mode of designation, seeing that in other evidently nearly allied forms (*e.g. D. divaricatus*, Hall) he regards the middle one of the three spines, in agreement with Hopkinson, as the sicula. Carruthers, in opposition to Hopkinson, regards the spine in the axillary hollow of the branches as the sicula; and Lapworth also expresses himself in the same sense, writing as follows:[3]—"It is simply this persistent sicula which constitutes the 'axillary spine' in *Dicellograptus*."

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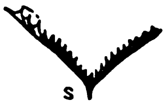
[1] "On *Dicellograptus*, a new genus of Graptolites," GEOL. MAG. Vol. VIII. (1871), No. 1. [2] "Monograph of the British Graptolitidæ" (1872), p. 65.
[3] "Notes on British Graptolites," GEOL. MAG. Vol. X. (1873), p. 501.

In the first place it must be noted that the presence or absence of this so-called axillary spine cannot at all affect the decision of the question whether we have or have not to regard it as the sicula, as not only this process, but also the middle one of the three processes placed side by side, is sometimes to be found, sometimes not. This is shown by Nicholson's figure[1] of *D. sextans*, Hall.

But if we compare the figures here given (Figs. 2–6) of representatives of various genera, the decision of the question before us seems to proceed directly from them. *Dicellograptus*, Hopk., occupies a middle position between *Didymograptus*, M'Coy, and *Dicranograptus*, Hall; it is placed in the immediate vicinity of the latter genus, and both are referred to the same family. In *Didymograptus* the sicula is quite visible, and no doubt is possible as to its position; in *Dicranograptus* the lower part of the two branches has grown together, and the sicula is thus imbedded. In the first case the pointed end of the sicula is actually upon the dorsal side of the branches, theoretically also in the second. In *Dicellograptus*, Hopk., the same position is occupied by the "axillary spine." *This is consequently the true sicula.*



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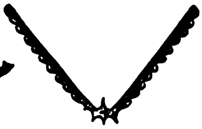

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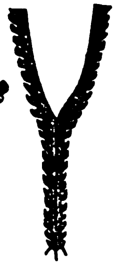

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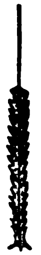

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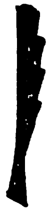

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FIG. 2. *Didymograptus vacillans*, Tullb., *Phyllograptus* shales, Norway. Nat. size. Original.

" 3. *Dicellograptus Forchhammeri*, Gein., Ireland. Nat. size. After Lapworth.

" 4. *Dicranograptus ramosus*, Hall, Hudson River Group, Canada. Nat. size. After Hall.

" 5. *Diplograptus angustifolius*, H., Ireland. Nat. size. After Lapworth.

" 6. *Monograptus gregarius*, Lapw., Upper Silurian, Scotland. Enlarged. After Lapworth.

We find a still greater difference of opinion when we endeavour to make out what the various authors understand by the *angle of divergence*. Not only do the individual naturalists support different views, but even one and the same author defines the idea of the angle in question differently in different parts of his writings. Hopkinson, for example,[2] in 1871, explains with regard to the genus *Didymograptus*, M'Coy, that the angle of divergence is the "angle included within the polypiferous margins of the branches"; but on a subsequent occasion[3] he says that in the genus *Didymograptus*, M'Coy,

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[1] Monograph of the British Graptolitidæ, p. 63.

[2] "On *Dicellograptus*," GEOL. MAG. Vol. VIII. (1871), p. 22.

[3] "On the Graptolites of the Arenig and Llandeilo Rocks of St. David's," Quart. Journ. Geol. Soc. vol. xxxi. (1875), p. 640.

"the angle of divergence is gradually carried through the various species from 180° almost to 360°," which is as much as to say that the angle of divergence is the angle formed by the dorsal "non-polypiferous" margins of the branches.

Several authors, in order to arrive at a definition of the angle of divergence, have started from the genus *Diplograptus*, M'Coy (Fig. 5), assumed the angle in question here, as shown in the figure, to be 0°, and then proceeded to *Dicranograptus*, Hall, *Dicellograptus*, and *Didymograptus*, and found for these genera the magnitudes 0°, ∠180°, ∠ 180°, and > 180° to ∠ 360°.

Another mode of definition seems to me to recommend itself as the more natural. The oldest two-branched Graptolite genus, which first of all induces us to think over the angle of divergence, is the genus *Didymograptus*, M'Coy. If we have an example of this genus before us (Fig. 2), we shall find it natural at the first glance to give as the angle of divergence the angle which the branches form on their cell-bearing side.[1]

The younger two-branched Graptolites following *Didymograptus*, M'Coy, in the sedimentary deposits, the *Dicellograpti* (Fig. 3) may then be regarded as *Didymograpti* the branches of which are bent further back. The above-indicated angle between the cell-bearing margins of the branches has become > 180°. In *Dicranograptus*, Hall, only the distal parts of the branches are in divergence, and the angle here formed by the cell-bearing margins of the branches (Fig. 4) varies between the same limits as in *Dicellograptus*, Hopk. The basal parts of the branches in *Dicranograptus* have grown together by their dorsal margins, so that the cell-bearing margins form an angle of 360°. Lastly, the genus *Diplograptus* (Fig. 5), which represents the Graptolites in their most perfect development, no longer possesses any visibly diverging branches; but the theoretical angle of divergence at which we have arrived step by step, from the genus *Didymograptus*, through *Dicellograptus* and *Dicranograptus*, amounts to 360°. In *Monograptus*, Gein. (Fig. 6), we cannot speak even of a theoretical angle of divergence.

This conception, which takes into account the geological age of the genera of Graptolites, may perhaps deserve consideration. *Under the term angle of divergence we therefore understand the angle formed by the cell-bearing margins of the branches.* This is as follows for the genera:—*Didymograptus*, M'Coy = > 0° to 180°.
Dicellograptus, Hopk. = 180° to ∠ 360°.
Dicranograptus, Hall = 360° and 180° to ∠ 360°.
Diplograptus, M'Coy = 360°.

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[1] The question of the angle of divergence appears to me to be a comparatively simple matter. Leaving out of consideration the two sides of the branches, the angle of divergence is that formed by the axial lines of the branches at their meeting-point in the sicula. Assuming the two branches to grow quite straight out from the sicula, there will be no angle of divergence (0°), and the celluliferous margins will be in contact;—then, as the branches diverge, sweeping round the imaginary circle of which the sicula is the centre (of course in the direction of the non-celluliferous margin, as otherwise they would have to cross each other), these axial lines will form gradually increasing angles, until the dorsal margins come close together, when we get 360° as in fig. 5. Roughly speaking, the angles shown in the figures would be, for fig. 2, about 90°; fig. 3, about 270°; fig. 4, 360°, and 330°; and for fig. 5, 360°.—W.S.D.

As regards the *former position of the Graptolites* in the living state, two different views are extant. Hopkinson, Lapworth, and Zittel represent all Graptolites with the acute extremity of the sicula always directed upwards, and state that in their opinion the Graptolites formerly lived in this position. A *Didymograptus* consequently turned the point upwards, and the two branches grew downwards. Other naturalists, as, for example, Hall, Nicholson, Tullberg, Linnarsson, and Brögger, choose such a position that the sicula, regarded as a point, is always placed below, while the branches stretch upwards.

Direct evidence as to the correctness of one or the other view cannot be obtained, seeing that from the position in which we now find their remains in the rock, we cannot ascertain what position the living animals took in the Silurian sea. After their death they fell to the bottom, and then laid themselves upon one side. Even in the expanded much-branched Dichograptidæ, the appearance of which, especially when a central disc is present, may have had some resemblance to that of a Medusa, no conclusion as to their former position can be drawn from their present position upon a rock-surface.

The zoologists, however, refer to the fossils of arborescent form which are certainly very nearly allied to the Graptolites, and lived at the same time with them. These, such as *Dendrograptus serpens*, Hopk., possess a true stem from which branches and twigs issue at one end, while the other end terminates in a radiciform nodule. These forms may very probably have been attached, or have lived so that the points of the twigs formed the superior extremities, but not so that the branched part was turned towards the depths, and the stem with its nodose termination directed upwards. Here, however, the nodose, and therefore probably the lower part, was undoubtedly the older, *i.e.* the starting-point. In *Dictyograptus*, Lapw., a genus which is also abundantly branched, there is no stem bare of branches; in it the whole hydrosoma runs out into a point (sicula). This is also the starting-point; the free extremities of the twigs are the younger parts of the hydrosoma. If we place the starting-point below in this case also, the whole hydrosoma represents a funnel opening upwards, certainly the natural position. If we reason in like manner in the case of *Didymograptus*, etc., there also the sicula must be placed at the bottom, and the branches and hydrothecæ represented as stretching upwards.

We have therefore regarded the sicula as an equivalent whole, without taking into consideration whether the budding takes place sometimes at its pointed, sometimes at its broader end. Prof. Leuckart very kindly called my attention to the resemblance between the Graptolites and existing animal forms, and upon the last-mentioned point I have, after mature consideration, adopted, with full conviction, the views of my honoured instructor. The Graptolites have, therefore, always been figured by me with the sicula below, and the branches directed upwards.

Funiculus.—Hall has given the name of "funiculus" to the part of the hydrosoma which, in the forms of Dichograptidæ possessing four, eight, or more branches, unites the two symmetrical halves, as well as to the parts of the branches situated nearest to the furcation-points. In the four-branched species the uniting transverse beam is said to be always destitute of cells; in those with eight and more branches neither the central part of the hydrosoma, nor the portions of the branches placed between the divisional points, are said to be cell-bearing, but the cell-bearing parts or "true branches" only commence beyond the last furcation-point. Hall himself, however, furnishes an exception to the rule thus established. The above remarks do not apply to *Clonograptus Milesi*, Hall, in which the hydrothecæ commence immediately beyond the first furcation-point.

Holm[1] states that Hall's assertion has also proved untrustworthy in other forms, and expresses the opinion that "in many cases, although not always, hydrothecæ also occur even upon these supposed naked spaces." He has actually detected distinct hydrothecæ upon the so-called funiculus in a Norwegian species of *Schizograptus*, Nich. When he had removed the periderm by means of a brush, he noticed the impression of a small hydrotheca on each side of the sicula.

The instances in which one is enabled to observe the under-surface of the so-called funiculus will be of excessive rarity in consequence of the repeatedly noted peculiar position of the branched specimens. Nevertheless it has appeared to me as if in my young individuals of *Tetragraptus quadribrachiatus*, Hall, a narrow streak of a hydrotheca peeped out here and there beneath the transverse beam.

Several specimens in my possession of the species *Dichograptus octobrachiatus*, Hall, and *D. Kjerulfi*, Herrm., are filled up with the rock-mass and have better preserved their original form. At the proximal end of each hydrotheca we observe a constriction on the dorsal surface of the branch which presents itself to the observer, so that the branch appears to consist of nothing but joints inserted one into the other, like the stem of an Equisetum. These depressions, each of which therefore corresponds to a hydrotheca, are not, however, found exclusively beyond the last furcation-point, but also here and there within the furcation-points upon the branches, a distinct proof that even the first divisions of the transverse beam, which, according to Hall, belong to the "funiculus," are furnished with hydrothecæ. In the specimens which give rise to the observations just cited, the transverse beam itself unfortunately was not well preserved, so that it could not be decided whether this does or does not bear hydrothecæ. It may, however, be assumed with the greatest probability that this is the case here as in many other species. Future observations will bring us certainty in this direction.

The discovery of these hydrothecæ in the vicinity of the sicula is rendered more difficult because at the proximal end of the hydrosoma (as at the distal end) the hydrothecæ gradually diminish in size, and are sometimes only of minute dimensions. Further, it may,

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[1] "*Pterograptus*, ett nytt Graptolitslägte," Öfv. Kongl. Vet. Ak. Förh. 1881, No. 4.

however, be indicated, that the branches of *Clonograptus multiplex*, Nich., and *C. flexilis*, Hall, have cells between the furcation-points. Finally, I will mention that a specimen of *Tetragraptus fructicosus*, Hall, collected by myself, distinctly shows a hydrotheca between the sicula and each of the two furcation-points. *T. fructicosus*, Hall, as is well known, has a mode of ramification different from that of the other *Tetragrapti*, for which reason one more readily manages to see the hydrothecæ in profile. The branch-segments situated between the sicula and the furcation-points are, however, here the same parts of the hydrosoma which are denominated the "funiculus" in the other *Tetragrapti*, and this part is sometimes celluliferous in *T. fructicosus*, Hall.

The facts brought together above show that the exceptions to Hall's rule are gradually accumulating. We begin to feel the necessity of dropping the definition of the funiculus as a cell-less part of the hydrosoma; but in any case the presence of such a naked stem is not to be employed as a means of separating genera and species from each other. The species founded upon such a criterion runs the risk of being upset by every fresh observation.

The Central Disc.—The most singular of all the parts of the Graptolite-body is undoubtedly the *central disc, i.e.* a chitinous membrane, which, in some much-branched Dichograptidæ, is extended between the basal parts of the branches. This peculiar organ was discovered by Hall, and gradually detected upon five different American species of the family Dichograptidæ, Lapw. Some of the American disc-bearing species were also soon found in the English Silurian deposits.

For the palæontologists upon the continent of Europe the description of this singular appendage had a peculiar interest, as it could not but be supposed that similar interesting forms would be discoverable in the strata which were regarded as of the same age as these American and English deposits. That these anticipations were founded upon a correct assumption was shown by the discovery of a comparatively thin but most productive bed of the expected and wished for forms. Those of this locality (Galgenberg in Oslo, a suburb of Christiania; Lower Graptolite-shales of Kjerulf; *Phyllograptus*-shales of Brögger) contributed to the completion of the analogy between the Norwegian, American, and English strata in question.

The number of species of Dichograptidæ with a disc has now been raised to seven, the names of which here follow: *Tetragraptus alatus*, Hall, *T. crucifer*, Hall, *T. Headi*, Hall, *T. approximatus*, Nich., *Dichograptus octobrachiatus*, Hall, *D. Kjerulfi*, Herrm., *D.* (*Loganograptus*) *Logani*, Hall. In specimens of *Climacograptus bicornis*, Hall, also, a similar membrane is sometimes observed, enveloping the base of the celluliferous stem and the processes issuing from the stem; and in some species of the genus *Dicellograptus*, Hopk. (e.g. *D. Moffatensis*, Carr.), the proximal parts of the two branches are also united by a similar membrane.

Hall, to whom we are indebted for all the information relating to the disc,[1] states that it consists of two laminæ, which are not united to one another in the central part; and he is of opinion that this space was occupied by the soft part of the animal body.

The central disc, as implied in its name, possesses a disc-like form, in the centre of which the sicula, the starting-point of the hydrosoma, is situated (Fig. 1). The margin of the disc is incurved between every two branches, so that the many-branched specimens present the aspect of an open umbrella. The diameter is of very different lengths. In specimens with long branches it may be very small, while in other, short-branched examples, it may be disproportionately large. The length of the diameter apparently stands in no regular proportion to the length of the branches, *i.e.* therefore to the age of the individuals. In several cases the formation of the disc has only just commenced in nearly mature specimens.

Nevertheless it appears distinctly from the observations that the disc can acquire greater dimensions the greater the number of ramifications, and that in the many-branched forms the disc is far more rarely wanting than in those with a smaller number of branches. As we find individuals in various stages of development in the Graptolite-shales, we can sketch a tolerably distinct picture of the course of development of the disc.

In individuals which have died in their earliest youth, nothing in the shape of a disc is to be recognized. In these, no secretion of the disc-substance had as yet commenced, or the central expansion, if present, was deficient in preservable hard structures. The first traces of the formation are perceptible in somewhat more mature specimens on the margin of the branches in the vicinity of the sicula. This stage of development is represented by forms in which, in the compressed state, we see a thin membrane stretched between the forks of the branches, that is to say, around the transverse beam uniting the two halves of the hydrosoma, and on the proximal parts of the 8, 12, or more branches.

The secretion advances further. The periphery of the disc increased; the disc-substance must have become thickest in the neighbourhood of the centre, and gradually diminished in strength towards the margin. We consequently meet with older individuals in which the central part of the disc is quite opaque, while the marginal parts are still delicate and translucent.

As the disc attained its complete development, this difference in strength disappeared gradually, the marginal parts acquiring a uniformly greater thickness by the continual advance of the substance outwards from the centre; and in fact, in its most perfect development, the disc forms a plate of uniform thickness.

But as a secretion of chitine could not proceed from the solid margins of the branches, but, as zoology teaches us, only from soft body-substance, we must assume that the disc, as indeed Hall supposes, was filled with soft substance in its central part. But how this was connected with the cœnosarc of the polypary has not yet been ascertained.

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[1] Geological Survey of Canada: Graptolites of the Quebec Group, Montreal, 1865, and Introduction to the Study of the Graptolites, Albany, 1868.

With regard to the function of the disc, Hall supposes that, on the one hand, it gave solidity and support to the basal parts of the branches, and on the other may have served other purposes of the animal economy. Such subsidiary functions of the disc may have been only of quite subordinate nature, seeing that in members of one and the same species the disc may be sometimes present and sometimes entirely absent, and its development commences sometimes in quite young individuals, sometimes in those which are nearly full grown. But as the disc occurs only in those forms in which the branches are remarkably thin in the neighbourhood of the sicula, and as, in consequence of the branches frequently being numerous and long, the central part of the organism had no small amount of resistance to furnish, this support may have been the principal if not the sole destination of the disc. This is rendered still more probable because the disc never occurs in other forms which possessed particularly stout branches, and in consequence of their mode of ramification had greater firmness, such as *Clonograptus multiplex*, Nich., *C. flexilis*, Hall, etc.

It does not appear to me probable that, as has been suggested, the Graptolites were attached by means of the disc, seeing that in very many specimens the disc is entirely uninjured, and even in those with damaged discs the kind of injury does not indicate their having been torn away, because it is precisely the central part that most rarely shows any damage.

HYDROTHECÆ.—We are indebted to Hopkinson for a new and important discovery with regard to the intimate structure of the Graptolites.[1] M'Coy, in 1854, in his "British Palæozoic Fossils," in the course of the description of a Graptolite, had spoken of "transverse septa," which were to be found at the proximal ends of the hydrothecæ, and had also represented the position of these septa in a figure. In 1868, Hopkinson had stated in connexion with this[2] that he had been unable to find "any indication of a dividing septum [in Graptolites], if we except a few forms in which there is an impressed line between the hydrothecæ and the periderm."

More recently Allman, in his "Monograph of the Calyptoblastic or Tubularian Hydroids," compared the hydrothecæ of the Rhabdophora with the sessile nematophores of the Plumulariæ, at the same time denying the presence of a septum or constriction, and indicating that later observations had not confirmed the existence of the septa mentioned by M'Coy.

Hopkinson[3] was quite recently in a position to investigate an abundant Graptolitic material from the Skiddaw slates, and he found in it specimens of *Didymograptus extensus*, Hall, *D. patulus*, Hall, and *Tetragraptus serra*, Brongn. (= *T. bryonoides*, Hall), which permitted the interior structure to be examined. In some of these specimens he was able to perceive that the hydrothecæ were separated from the cœnosarc by a well-marked septum, and that the cœnosarc itself appeared to be divided into separate joints by transverse septa. Hopkinson figures a branch of *T. serra*, Brongn., which was obtained in section and filled with mineral substance. The common canal, which had been occupied by the cœnosarc, has the appearance of a vertebral column, and between each two rectangular joints we see a septum. When the mineral substance was removed, Hopkinson observed a series of rectangular impressions, separated from each other by transverse walls or "ridges." A similar ridge separated each depression from the hydrotheca belonging to it.

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[1] Ann. Mag. Nat. Hist. Jan. 1882, pp. 54-57.

[2] Journ. Quek. Micr. Club, vol. i. p. 161.

[3] Ann. Mag. Nat. Hist. Soc. ser. 5, vol. ix. (1882), pp. 54–57.

The hydrothecæ, says Hopkinson, appear to have budded from the cœnosarc as the leaves of an exogenous tree bud from the stem, and not to have been continuous with their support like the leaves of endogenous trees. The partition is not a true septum, but only "a ridge, a constriction, occasionally forming a very sharp line of demarcation, but in most cases scarcely, if at all, perceptible."

The structure here described occurs in the existing Thecaphora, and Hopkinson thinks that "it can now no longer be maintained that the calycles of the Graptolite are not true hydrothecæ":—Kirchenpauer, also, in opposition to Allman, treats the cells of the Graptolites as hydrothecæ.

As regards the REPRODUCTION and ZOOLOGICAL POSITION of the Graptolites, no new views have, so far as I know, been recently put forward, so that here we may refer to the excellent section upon the Graptolites in Zittel's "Handbuch der Paläontologie," in which the principal opinions are brought together and discussed briefly and clearly.

When Hall describes specimens of *Diplograptus*, M'Coy, with sac-like appendages, and regards these appendages as gonangia, we can only be surprised that among the innumerable specimens of *Diplograptus* from the earliest to the most advanced age which the graptolite collector has the opportunity of studying, such sexual individuals have never turned up. But I have carefully looked for them in vain.

On the other hand, I brought home a hand-specimen which was sprinkled with small round or oval corpuscles, vividly reminding me in form and structure of the supposed ovarian capsules (*Dawsonia*) of the Graptolites figures by Nicholson.[1] These, like the fragments of Graptolites accompanying them, are converted into grey, shining mineral (Gümbelite?) But unfortunately the same beds contained not unfrequent although always isolated specimens of a Brachiopod (*Obolus!*) which has on the surface a striation exactly like that of the small, round bodies. This Brachiopod always appears black and lustreless, and is about six times the size of the latter. Finding at a higher level (zone of *Didymograptus Murchisoni*, Beck, Nordal-Bruns Strasse, Christiania) fragments of slate filled with innumerable small, black, undoubted Brachiopoda (*Obolella?*), I became doubtful, and could arrive at no definite answer to the question as to what the grey, shining bodies should be taken for. I must, however, admit that my material was very scanty, and that special investigations can only be made when it is made more complete.

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[1] Ann. Mag. Nat. Hist. (1873), ser. 4, vol. xi. p. 140.

The state of the case is therefore as follows: In the ***Phyllograptus*-schists** light grey, shining Graptolites are associated with numerous small, rounded bodies of the same colour, and with isolated, larger, black, lustreless Brachiopoda. In the zone of ***Didymograptus Murchisoni*** we meet with light grey, shining Graptolites associated with numerous small, rounded Brachiopoda, with a lustreless, black surface, with a few isolated, larger, black, lustreless Brachiopoda.

This brings to a close the considerations upon the organization and economy of the Graptolites. We have taken as the starting-point the often cited section in Zittel's "Handbuch der Paläontologie," and refrained from repeating here all those newer views which are referred to in it, and which did not call for any comment.

IV.—NOTES ON THE BRITISH SPECIES OF *CERATIOCARIS*.

By Prof. T. RUPERT JONES, F.R.S., and HENRY WOODWARD, LL.D., F.R.S.

(Concluded from September Number, p. 397.)

5. CERATIOCARIS INORNATA, M'Coy.

1851.	*Ceratiocaris inornatus* (Salter MS.),	M'Coy.	Brit. Pal. Fos. p. 137, pl. 1 E. f. 4.
1854.	,, ,,	Morris.	Catal. Brit. Foss. 2nd edit. p. 102.
1859.	,, ,,	Salter.	In Siluria, 2nd (3rd) edit. p. 532.
1860.	,, ,,	Salter.	Ann. Mag. Nat. Hist. ser. 3, vol. v. p. 156.
1867.	,, ,,	Salter.	In Siluria, 3rd (4th) edit. p. 516.
1873.	,, ,,	Salter.	Catal. Camb. Sil. Foss. pp. 177, 178.
1877.	,, ,,	H. Woodward.	Catal. Brit. Foss. Crust. p. 71.

This is the third of M'Coy's original species. The specimen in the Cambridge Museum has its carapace ovate-oblong or somewhat boat-shaped in outline, 50 mm. (2 inches) long, 18 mm. high; moderately convex; straight or very slightly arched above and more strongly arched below (both edges are partly imbedded in the matrix of the original specimen, *b*/5, M'Coy's fig. 4). The anterior end (damaged) was neatly rounded, sloping up gracefully from below. The posterior is obliquely truncate from above downwards and outwards, with the postero-dorsal angle distinct, and the postero-ventral angle prominent and blunt. There is no eye-spot. Traces of longitudinal striæ are visible on the impressions of the valves in the grey, micaceous, Upper-Ludlow sandstone, from Benson Knot, near Kendal, Westmoreland; two specimens (one of them good) are in the British Museum, No. 44342, from the same locality.

The foregoing description does not quite tally with the account of the species in the Brit. Pal. Foss. p. 137, nor with that in the Ann. Mag. N. H. *l.c.*, but is based on the original specimen, and not on the *restored* figure in the Brit. Pal. Foss. The figure annexed by Mr. Salter to his note on *C. inornata* in the Catal. Camb. Sil. Foss. 1873, p. 178, is used also in connection with two other species at p. 16 and p. 164. In the latter case it is probably intended for *C. leptodactylus*, which we recognize as *C. Murchisoni*.

C. inornata approaches *C. papilio* in form in some cases, but we think that they are quite distinct species. There are some small carapaces, one from Lesmahago, B.M. 59648, very near to *C. papilio* in form, and measuring 34 × 13 mm., and one from Benson Knot, B. M. 44342, measuring 35 × 14 mm. These proportions are different from those of *C. papilio.* These two are rather smaller than M'Coy's original *C. inornata* (about 50 × 20 mm.), but have the same proportions, the normal height being 2½ of the length; whilst *C. papilio* is larger and has less height in proportion, the length being only twice the height, or even less.

6. CERATIOCARIS ORETONENSIS, H. Woodward.

1871. *Ceratiocaris Oretonensis*, H. Woodward. GEOL. MAG. Vol. VIII. p. 105, Pl. III. Fig. 1.
1878. " " H. Woodward. Cat. Brit. Foss. Crust. p. 71.

This Carboniferous species, described in the GEOL. MAG. for March, 1871, approaches closely to some of the forms of *Ceratiocaris* found in the Upper Silurian of Benson Knot—namely, *C. inornata*, M'Coy. The carapace (50 × 22 mm.) is larger, however, without attaining the size and proportions of *C. papilio*, which is also found there, and is not without an apparent relationship to the former, as already noticed (p. 394). In again examining the specimens, we find that the anterior end is not so much rounded as in Fig. 1, but is slightly and obliquely truncate; and the antero-ventral margin more sloping and less convex; thus the greatest depth of the carapace is in the hinder half. Four specimens from the Yellow Carboniferous Limestone of Oreton and Farlow, Worcestershire, not well preserved. The indistinct 'eye-spot,' mentioned at p. 105, is very problematical, and may have been caused by pressure on some internal organ (teeth ?).

7. CERATIOCARIS TRUNCATA, H. Woodward.

1871. *Ceratiocaris truncatus*, H. Woodward. GEOL. MAG. Vol. VIII. p. 106. Pl. III. Fig. 2.
1878. " " H. Woodward. Cat. Brit. Foss. Crust. p. 72.

The smaller species occurring with the last (*C. Oretonensis*) was described and figured with it in 1871. The carapace (35 × 15 mm.) is well figured, except that (as the author remarks, p. 106) the slightly concave truncation of the hinder end is not well rendered by the artist. Its smaller size, sharp antero-dorsal angle, and nearly even ventral curve, distinguish it from its associates, but scarcely separate it as far as the outline is concerned from some specimens of *C. inornata* at Benson Knot.

8. CERATIOCARIS SOLENOIDES, M'Coy.

1849. *Ceratiocaris solenoides*, M'Coy. Ann. Mag. N. H. ser. 2, vol. iv. p. 413, with woodcut.
1851. " " M'Coy. Brit. Palæoz. Foss. fasc. i. p. 138, pl. 1 E. figs. 5, 5*a*.
1854. " " Morris. Catal. Brit. Foss. 2nd ed. p. 173.
1860. *Cultellus ? (Ceratiosolen ?) rectus*, Salter. Ann. Mag. N. H. ser. 3, vol. v. p. 160.
1873. *Ceratiocaris solenoides*, Salter. Cat. Camb. Sil. Foss. p. 178.
1877. " " H. Woodward. Catal. Brit. Foss. p. 178.

Prof. M'Coy founded the genus on this species and *C. elliptica* in 1849.

The original specimens in the Cambridge Mus. (*b*/40, *b*/41) are not exactly drawn in M'Coy's figs. 5 and 5*a*. The carapace is elongate, sub-cylindrical, slightly convex on the sides, with an even elliptical anterior curve, and an oblique truncation posteriorly. There are faint traces of longitudinal striæ on the hollow impressions of the valves in the matrix, and there is a slight trace of the ventral rim. The large one is 43 mm. long (fig. 5); the smaller specimen (fig. 5*a*) 27 mm., is apparently broken behind, but does not show the double valve there as given in the figure; we cannot distinguish any "nuchal furrow," nor is there any "eye-spot": a mark consisting of two minute adventitious pits in the anterior third of one of the specimens, and a little hole in another, have been mistaken for it. Mr. Salter thought these little fossils were Molluscan;[1] but they certainly may well claim to be Phyllopods. There are other specimens in the Cambridge Mus.; also two small individuals, one 19 mm. and the other only 10 mm. (marked *f*/142) in length. In the Brit. Mus. there are four, rather large, but not well-preserved specimens (44342). All the above come from the Upper-Ludlow grey micaceous sandstone of Benson Knot, near Kendal, Westmoreland.

9. CERATIOCARIS GOBIIFORMIS, *sp. nov.*

A form closely approaching *C. solenoides* in shape, but smaller, more acute in front, usually more vertically truncate behind, and much more convex on the ventral border, accompanies *C. solenoides* in the Upper-Ludlow sandstone of Benson Knot. One of the specimens marked *b*/8, Camb. Mus., is 27 mm. long by 9 mm. high; one in the Brit. Mus., No. 44342, is 30 by 10 mm.; M. P. G. x $\frac{1}{18}$ (Catal. 1878, p. 142) is 31 by 11 mm. The valves seem to have been smooth. They distantly resemble in outline a deep-bodied, blunt-headed little fish, without its tail. It is possible that this may be a varietal or sexual form of *C. solenoides*, but it seems to be sufficiently well separated from its ally to require a distinctive name, so we refer to it as *C. gobiiformis* in our list.

10. CERATIOCARIS SALTERIANA, *sp. nov.*

Six specimens in different states of preservation, from the Lower-Ludlow strata, indicate the existence of a distinct species of *Ceratiocaris*, having a nearly oblong carapace, ornamented with delicate but strong horizontal parallel lines, rather wide apart.

Specimen Ludlow Mus. K., from Trippleton, near Leintwardine, has a carapace (23 × 12 mm.), five (?) abdominal segments (10 mm.), and appendages, of which the style (pitted with bases of little spines) is imperfect, but a stylet measures 5 mm.

Another carapace M. P. G. $\frac{22}{14a}$, from Bow Bridge, Ludlow, well preserved, is 30 × 15 mm., straight on the back, rounded at the ends, the front being highest, and the greatest depth of the carapace being at the anterior third of the ventral margin. A hinder moiety of another carapace accompanies the last mentioned.

In the Cambridge Univ. Mus. *a*/694 is a similar carapace nearly as well preserved (30 × 14 mm.). The ventral margin has a distinct raised rim. The striæ and interspaces differ in tint of colour on the cast. Some internal organs (teeth?) have caused a little break or hole and a derangement of the striæ in the antero-dorsal region. This specimen is from the Lower-Ludlow Shale at Dudley.

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[1] See Ann. Mag. Nat. Hist. *l.c.* p. 159, *note;* and Sedgwick's Lists of Kendal Fossils; Wordsworth's Letters on the Lakes, 1843–46, Appendix.

Two specimens in the Oxford Mus. L. & M. evidently belong to this species.

We wish to associate this rare but distinct species of *Ceratiocaris* with the name of our deceased friend, Mr. J. W. Salter, who worked so long and so well on these and allied *Phyllopoda*.

11. CERATIOCARIS CASSIA, Salter.

1860. *Ceratiocaris cassia*, Salter. A. M. N. H. ser. 3, vol. v. p. 159.
1867. „ „ Salter. In Siluria, 3rd (4th) edit. p. 516.
1877. „ „ H. Woodward. Cat. Brit. Foss. Crust. p. 70.
1878. „ „ Huxley and Etheridge. Cat. C. S. Foss. M.P.G. p. 141.

The best-preserved carapace-valve (22 × 11 mm.) we have seen is Brit. Mus. 44342, from the Upper Ludlow of Benson Knot; Brit. Mus. 38400, from the Lower Ludlow of Leintwardine, is also good, but is crumpled so as to have its outline modified. Originally nearly oblong, slightly arched above and below, truncate with hollow curve behind, pointed and mucronate at the upper third in front. Ludlow Mus. E. and F. and M. P. G. x $\frac{1}{4}$ (Catal. C. S. Foss. 1878, p. 141), seen by Mr. Salter, are not quite perfect. They are from a roadside quarry S.E. of Trippleton Farm, near Leintwardine. Ludlow Mus. F. and Brit. Mus. 39400 retain traces of the abdomen: in the latter, 15 mm. long, without appendages; in the former much less is seen, and a short telson (about 5 mm.). The carapace is horizontally striate, and the telson is minutely pitted as if it had been spinose. The ventral margin had a delicate raised rim.

Ludlow Mus. H., also from Trippleton, is a very small oval relic of a valve (13 × 7 mm.) possibly of *C. cassia*, and a loose abdomen of 5–6 segments (16 mm.), with a neat little set of appendages, style, 6 mm., and two stylets, each 3 mm.

Ludlow Mus. G. may be a modified carapace of *C. cassia*, no locality is recorded for it.

12. CERATIOCARIS, *sp. nov.?*

Mus. Pract. Geol. x $\frac{1}{26}$ (Catal. C. S. Foss. 1878, p. 142), labelled *C. vesica*, is a small specimen, having its carapace and abdomen preserved in place. From the Lower Ludlow of Leintwardine. It differs very much from *Physocaris vesica*, although nearly of the same size. The carapace is subtriangular, 25 mm. long and 15 mm. deep at the middle of the ventral margin. The back is straight, but curved down at both ends to meet the steep upward slopes of the lower margin. The abdomen (15 mm.) comes out, as usual, from the upper part of the hinder region. It shows obscurely four segments (the ultimate one about 6 mm.), mostly striated obliquely. The appendages have been broken off short. The carapace is somewhat crumpled, and is roughened anteriorly, probably by the presence of internal organs (such as teeth, etc.).

It is possible that this may be a very young individual of *C. stygia*, to which it somewhat approximates by its subtriangular carapace, and its obliquely-striate segments. Otherwise it must be a distinct species.

Specimen Lud. Mus. J. (from Trippleton, near Leintwardine) has a smaller but nearly similar carapace (22 × 12 mm.); nearly straight on the back, deeply curved below, and with almost equal dorsal angles in front and behind, but sharp instead of being blunt.

13. CERATIOCARIS ROBUSTA, Salter.

1851. *Pterygotus leptodactylus*, M'Coy (in part). Brit. Palæoz. Foss. fasc. i. p. 175, pl. 1 E. figs. *7c*, *7d*.
1860. *Ceratiocaris robustus*, Salter. Ann. Mag. N. H. ser. 3, vol. v. p. 158.
1867. ,, ,, Salter. In Siluria, 3rd (4th) edit. p. 516.
1873. ,, ,, Salter. Cat. Camb. Sil. Foss. p. 164.
1877. ,, ,, H. Woodward. Cat. Brit. Foss. Crust. p. 71.
1878. ,, ,, Huxley and Etheridge. Cat. Camb. Sil. F. M. P. G. p. 142.

This species was founded on the caudal appendages of a form the carapace of which has not yet been collated. The original specimens figured by M'Coy and referred by Salter to a new species are in the Cambridge University Museum (*a*/925, fig. 7*c*; *a*/926, fig. 7*d*). The telson, 32 mm. long (longer than the figure), is straight, broadly ensiform, 6 mm. broad at its base. The stylets, 20 mm. long, are also relatively broad and ensiform or sharp-blade-like. They all seem to have once been faintly fluted and ridged or costulated. They were from Leintwardine (Lower Ludlow).

Two similar specimens, collected by the late Mr. Lightbody in Upper Ludlow beds, "above Ashley Moor," are in the Owens College Museum, Manchester. One of the sets, however, has the stylets nearly as long as the style: whether this was due to variation of growth or to accident, we cannot now decide.

B. M. 39404, from Leintwardine, belongs to the same species, though the style is rather longer (35 mm.).

Also M. P. G. $\frac{1}{17}$ (Catal. 1878, p. 142), from Leintwardine, seems to belong to this form. It shows two segments and appendages. Style, 40 mm.; one stylet present, broad and ensiform, 25 mm. long.

Specimens A. and H. in the Oxford Museum are good examples of *C. robusta*, of rather large size, the style of one being 45 mm. long, and of the other 35 mm. Some segments also are in place, and show a neat imbricate ornament of angular raised lines, passing downwards on the sides into delicate oblique wrinkles. S. and T. in the same Museum are short trifids with broad style and stylets agreeing more closely with M'Coy's original specimens. They are faintly fluted, and there are on one style two rows of the bases of little prickles. All from the Ludlow formation.

Var. *longa*.

Specimen Ludlow Museum M. is a broad and much longer telson (at least 75 mm. long), with linear ornament, from the Lower Ludlow at Bow Bridge, Ludlow. A small part of a slightly curved ensiform stylet shows from beneath it. This may be either a variety of *C. robusta*, or possibly a distinct species, near to *C. papilio*.

14. CERATIOCARIS, *sp. nov.*?

In Owens College Museum, Manchester, is a very delicate little set of caudal appendages. The style (central) shows a rounded section at its insertion, about 2 mm. wide, is 12 mm. long, tapering gently to a sharp point. The lateral stylets are 8 mm. each. All are delicately ridged and fluted. From the Lower-Ludlow or Aymestry Limestone, on the old road at Mocktree; collected by the late Mr. Lightbody.

Mus. Pract. Geol. D $\frac{22}{14}$ (Catal. C. S. Foss. 1878, p. 118), from the Lower Ludlow at Leintwardine, is a somewhat similar little set of appendages (three spines). The middle one is the longest, 8 mm., the others 6 mm.

These may belong to a very young condition of some of the species above mentioned, or possibly to a distinct species.

In the British Museum one of those marked 58878, from Linburn, near Muirkirk, shows a style (21 mm.), tapering, with circular section at base, and apparently smooth, together with a corresponding attached stylet, 16 mm. long. Were these not smooth, they might be referred to the same species as the foregoing smaller specimens. This set differs from the appendages of either *C. papilio* or *C. stygia.*

15. CERATIOCARIS DECORA, Phillips.

1848. *Onchus decorus,* Phillips. Mem. Geol. Surv. vol. ii. part 1, p. 226, pl. 30, figs. 5, 5*a*.
1867. *Ceratiocaris decorus,* Salter. In Siluria, 3rd (4th) edit. p. 516.
1877. „ „ H. Woodward. Cat. Brit. Foss. Crust. p. 70.

This is a small obscure style (?), 13 mm. long, from the Ludlow beds, of Freshwater-East, Pembrokeshire.

16. CERATIOCARIS (?) ENSIS, Salter.

1860. *Ceratiocaris? ensis,* Salter. Ann. Mag. N. H. ser. 3, vol. v. p. 159.
1867. „ „ Salter. In Siluria, 3rd edit. p. 516.
1877. „ „ H. Woodward. Catal. Brit. Foss. Crust. p. 71.

In the Grindrod Collection, Oxford Museum, specimen O, we find the original fossil described by Mr. Salter in 1860, namely, a large telson nearly six inches long, tapering, curved, lying on its side, and flattened, crenato-serrate on its convex (dorsal) edge, pitted along its inner (concave) margin, thickened at its proximal or articular end, sharp at the other; with a slight ridge along the middle of the exposed face. From the Lower Ludlow at Leintwardine, near Ludlow.

17. CERATIOCARIS (?) LATA, Salter.

1866. *Hymenocaris? latus,* Salter. Mem. Geol. Surv. vol. iii. p. 240.
1866. *Ceratiocaris? latus,* Salter. *Ibid.* p. 294, woodcut fig. 5.
1867. „ „ Salter. In Siluria, 3rd (4th) edit. p. 516.
1873. „ „ Salter. Cat. Camb. Sil. Foss. p. 16.
1877. „ „ H. Woodward. Cat. Brit. Foss. Crust. p. 71.

The specimen is in the Cambridge Museum (*b*/299?), and shows 5 (?) abdominal segments crushed endwise, so as to be shortened (12 mm.) and widened (28 mm.). The woodcut referred to is a *restoration.* The specific, and even generic, relationship is obscure. From the Tremadoc Slate, at Garth, east of Portmadoc; collected by Mr. D. Homfray.

18. CERATIOCARIS (?) INSPERATA, Salter.

1866. *Ceratiocaris ? insperatus*, Salter. Mem. Geol. Survey, vol. iii. p. 295.
1867. „ „ Salter. In Siluria, 3rd (4th) edit. p. 516.
1873. „ „ Salter. Cat. C. S. Foss. p. 16.
1877. „ „ H. Woodward. Cat. B. F. Crust. p. 71.

In the Cambridge Museum (A/275). Obscure remnant of an ultimate abdominal segment, with clear indications of a trifid appendage; the telson or central spine seems to be the longest, but all three are broken off above their points. The telson is about 35 mm. long. From dark-grey shales between the Lower and Upper Tremadoc Slates in a railway cutting above the village of Penmorfa, Portmadoc. Collected by Mr. D. Homfray. Mr. Salter thought that it belonged to the same species as the foregoing.

19. CERATIOCARIS (?).

An obscure hinder moiety (25 × 12 mm.) of a carapace possibly referable to *Ceratiocaris*, is in the Mus. Pract. Geol. $\frac{1}{6}\frac{2}{4}$, Catal. C. S. Foss. 1878, p. 72. From the "Upper Llandovery; Onny River."

20. CERATIOCARIS (?) PERORNATA, Salter.

1878. *Ceratiocaris ? perornatus* (Salter MS.), Huxley and Etheridge. Catal. Cambrian and Sil. Foss. M. P. G., p. 142.

An obscure form, known from only three small fragments, two of which are pitted all over, and one is tuberculate, like an Echinoderm spine. From Benson Knot, Kendal.

21. CERATIOCARIS (?) ELLIPTICA, M'Coy.

1849. *Ceratiocaris ellipticus*, M'Coy. Ann. Mag. N. H. ser. 2, vol. iv. p. 413.
1851. „ „ M'Coy. Brit. P. Foss. fasc. i. p. 137, pl. 1 E. fig. 8.
1854. „ „ Morris. Catal. Brit. Foss. 2nd edit. p. 103.
1859. „ „ Salter. In Siluria, 2nd (3rd) edit. p. 538.
1860. „ „ Salter. Ann. Mag. N. H. ser. 3, vol. v. p. 157.
1867. „ „ Salter. In Siluria, 3rd (4th) edit. p. 516.
1873. „ „ Salter. Catal. Camb. Sil. Foss. p. 178.
1877. „ „ H. Woodward. Catal. Brit. Foss. Crust. p. 71.

This interesting species, one of the first two established, is represented in the Cambridge Museum by specimen *b*/15 (M'Coy's fig. 8), and in the Museum of Practical Geology by $\frac{2}{3}\frac{3}{2}$ (Catal. 1878, p. 118) and x $\frac{1}{10}$ (Catal. p. 142). The carapace is long-ovate in outline, not very convex, greatest convexity of surface and curvature of ventral margin "at about one-third from the anterior end"; obliquely rounded in front; obliquely truncate at the upper portion of the hinder end. There is a spot like a definite ocular tubercle in the anterior fourth and above the median line of each valve, and this gives it a distant likeness to a guinea-pig's profile. The surface is neatly marked with delicate, longitudinal, parallel lines, rather far apart. The published figure of the specimen, *b*/15 (32 mm. long and 13mm. high) is reversed, and drawn too angular behind. It came from the Upper Ludlow Sandstone of Benson Knot. Specimen M. P. G. $\frac{2}{3}\frac{3}{2}$ is from the Lower-Ludlow beds of Leintwardine, near Ludlow, and is not quite so large nor so well preserved as *b*/15. Specimen M. P. G. x $\frac{1}{10}$, from the Upper-Ludlow of Combe Wood, Presteign, is larger and more ovate or elliptical than the others, but, unfortunately, is imperfect. The last two have been incorrectly labelled *C. Murchisoni.* In 1860 Mr. Salter thought that *C. elliptica* was only a badly-preserved variety of *C. inornata* (A. M. N. H. *l.c.*), but in the Catal. Cambr. Sil. Foss. p. 178, he recognized it as "quite distinct."

The above-mentioned three specimens supply the only evidence of an eye-spot in these British Ceratiocaridoid Phyllopods.[1] It is not only a generic character distinguishing them from *Ceratiocaris*, but an important family distinction, of which, for the present, we do not propose to estimate the value.

22. PHYSOCARIS VESICA, Salter.

1860. *Ceratiocaris (Physocaris) vesica*, Salter. Ann. Mag. N. H. ser. 3, vol. v. p. 159, woodcut fig.
1865. *Ceratiocaris (Physocaris) vesica*, Salter and H. Woodward. Catal. Chart. Foss. Crust. p. 17, fig. 8.
1867. *Ceratiocaris vesica*, Salter. In Siluria, 3rd (4th) edit. p. 517.
1877. *Ceratiocaris (Physocaris) vesica*, H. Woodward. Cat. Brit. Foss. C. p. 72.
1878. *Ceratiocaris vesica*, Huxley and Etheridge. Cat. C. S. Foss. p. 142.

Of this curious fossil Phyllopod, described carefully by Mr. Salter in 1860, only one specimen is known—namely, Ludlow Museum U. It differs slightly from Mr. Salter's figure, being larger, and showing an appearance of having been probably broken away to a little extent just above the front, so as to leave a notch and angle, which constitute the prominence in the woodcut figure. If continued over this notch, the outline of the shell would possibly be that of a broad oval; whereas now it is broadly and obliquely pyriform (25 × 20 mm.). The relative position of the animal is supposed to be indicated by the telson occupying the upper part of the abdominal appendages attached to the fossil. There are 8–9 segments in the abdomen, which appears to come out from the lower and hinder quarter of the carapace, and is very slender near its origin, but higher at its ultimate segment (5 mm. long); altogether 30 mm. The telson itself is 11 mm. long. One lateral spine (stylet), 7 mm., is present. The whole animal is about two inches long.

It was collected by the late Mr. Salwey in the Lower Ludlow at Leintwardine, and Mr. Salter at first registered it as *Ceratiocaris inflata.*

NOTICES OF MEMOIRS.

STUDIES IN THE DISTRICT OF THE BOHEMIAN CHALK FORMATION. THE WEISSENBERG AND MALNITZ SCHISTS. By DR. ANTON FRITSCH, Prague.

STUDIEN IM GEBIETE DER BÖHMISCHEN KREIDEFORMATION. DIE WEISSENBERGER UND MALNITZER SCHICHTEN. Mit 155 Holzschnitten. DIE ISERSCHICHTEN. Mit 132 Textfiguren. Von Dr. ANTON FRIČ. (Archiv der naturw. Landesdurchforschung von Böhmen, IV. Band, No. 1., V. Band, No. 2.)

IN these two memoirs Dr. Fritsch gives, in considerable detail, a petrographical and palæontological description of three of the eight divisions into which the Cretaceous series of Bohemia has been divided. Numerous profiles of sections and well-executed figures of the principal fossils accompany the text.

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[1] The "ocular tubercles," mentioned in the footnote at p. 236, Siluria, 3rd (4th) edit. 1867, are doubtless really due to the presence of "teeth" within the valves.

From a slight sketch of the Cretaceous strata as a whole, it seems to present the characters of a littoral or comparatively shallow-water deposit. Although no very close comparison can be made between it and the deeper-water deposits of the same formation in France and England, yet it has been ascertained that the Bohemian Cretaceous series corresponds only to the Cenomanian, Turonian and part of the Senonian, and therefore the Gault and the divisions of the Lower Cretaceous are absent below; and its highest zone is below that of *Belemnitella quadrata.* By Prof. Krejči and the author, the Bohemian series has been divided, chiefly on palæontological grounds, into eight divisions, which, with the exception of the lowest, are of marine origin. The lowest or Perucer division consists of sandstones containing a rich Flora and some sparse remains of Verbebrates, Molluscs, and Insects. These beds rest unconformably on Silurian or Carboniferous strata, and are of Lower Cenomanian age. The division above, or Korycaner beds, are limestones, sandstones, and conglomerates, characterized by *Trigonia sulcataria*, *Pecten asper*, and *Ostræa diluviana.* Next above are the Weissenberg and Malnitzer beds, principally of sandstones—some glauconitic—of Turonian age. The former of these divisions contains numerous fish-remains, many of which are identical with those of the Chalk at Lewes; some of the other fossils present are also common to the French Craie Chloritée. The Iser, Teplitzer, Priesener and Chlomeker divisions are regarded as Senonian. From the first of these the author enumerates 175 species of fossils; the details of the latter yet remain to be worked out.

REVIEWS.

MEMOIRS ON EXTINCT NORTH-AMERICAN VERTEBRATES, by Professor E. D. COPE, in the *American Naturalist.*[1] (Extinct Rhinoceroses and their Allies, Dec. 1879; Extinct Cats, Dec. 1880; Extinct Dogs, March, 1883; Permian Batrachia, Jan. 1884; The Creodonta, March and April, 1884; The Tertiary Marsupialia, July, 1884; The Condylarthra, Aug. and Sept. 1884; The Amblypoda, Dec. 1884 and Jan. 1885; The Lemuroidea and Insectivora, May, 1885.)

IN this valuable series of contributions to a knowledge of the marvellous extinct Vertebrate Fauna of North America, Prof. Cope informs us in a letter that he has intended to give a *résumé* in a somewhat popular form of work which either has been or will be published in fuller detail as opportunity occurs.

Before briefly noticing a few of the more interesting forms, we must premise that we are scarcely prepared to accept the extremely complex classification of the Mammalia which Prof. Cope propounds;

[1] We have only space to cite a few from this large series of memoirs.

and that in our own opinion it is preferable, as fresh discoveries indicate forms connecting groups widely separated at the present day, to unite those existing groups rather than to form fresh ones for the reception of the intermediate forms. Thus, taking the ungulated mammals as an instance, we find that on page 1121 of the memoir on the 'Amblypoda,' there are four so-called orders respectively named the Diplarthra, the Amblypoda, the Taxeopoda, and the Proboscidea; all of which we think are best included in the order Ungulata, as it is now very generally employed by English palæontologists. Even if this view were not accepted, it would surely have been preferable to retain the term Ungulata for the two suborders Perissodactyla and Artiodactyla (the Ungulata Vera of some English writers), rather than to invent for them the entirely new term Diplarthra, in which guise they are scarcely recognizable by the student of recent zoology. Similarly the recent Hyracoidea are relegated to a minor group of the so-called order Taxeopoda, when we should have thought it would have been better to retain the former well-known term in the larger sense, and include in it (of course presuming that the affinity be a real one) the allied fossil forms.

Another instance occurs in the case of *Hyænodon* and a host of allied extinct forms, which (together with some of the recent Insectivora) Prof. Cope ('The Creodonta,' *op. cit.*) refers to the suborder Creodonta of a large heterogeneous order Bunotheria;—the remaining Insectivora (judging from an earlier work) being regarded as another suborder of equal value with the Creodonta. Now we confess that we are unable to accept the division of the modern Insectivora as here proposed; and we think that as *Hyænodon* and its allies may be pretty safely regarded as ancestral forms connecting the modern Carnivora and the Insectivora by almost insensible gradations, it would be preferable that they should be affiliated to one or other of these orders,—our inclination tending to the Carnivora. This appears to us as a more advantageous plan than creating a suborder of a new order, which, after all, cannot be rigidly defined. That the result of this affiliation would be the impossibility of drawing any definite line of demarcation between the Carnivora and the Insectivora, we are fully prepared to admit; and if any change were to be made in reference to these orders, we should prefer the inclusion of the latter, as a suborder, in the former. Regarding, then, the so-called Creodonta as affiliated to the Carnivora, it may be remarked that these early insectivoroid forms lacked the grooved astragalus, and the compound scapholunar of the modern Carnivores; the absence of these specialized characters being precisely what we should expect to find in early generalized forms, which may have been ancestral both to the Carnivora and the Insectivora.

In regard to his families and genera, Prof. Cope is logically consistent to his views of the value of ordinal groups, and consequently makes them more numerous than we ourselves should be disposed to consider advisable. After all, however, these different views of classification are but matters of comparatively minor moment, which depend to a great extent on the mode of thought of each individual writer—a more complex system appearing to one mind to convey best the idea of mutual affinities, which would be equally well conveyed to another by a simpler arrangement.

With these preliminary remarks we may proceed to a short notice of the various memoirs quoted above.

Rhinoceroses and their Allies.—The Rhinoceroses are divided into the two families Hyracodontidæ and Rhinocerotidæ (Rhinoceridæ); the latter being split up into the genera ***Aceratherium*** (1), ***Diceratherium*** (2), ***Aphelops*** (3), ***Ceratorhinus*** (4), ***Zalabis*** (5), ***Rhinoceros*** (6), ***Atelodus*** (7), and ***Cœlodonta*** (8). ***Zalabis*** was made for the reception of the Siwalik ***Rhinoceros sivalensis***, but the characters on which it was founded have been shown in the publications of the Geological Survey of India to have originated in a mistake. We are inclined to follow the view of Prof. Flower in including Nos. 4, 7, 8, and perhaps 2, in ***Rhinoceros***. The European species of ***Aceratherium*** have no nasal horn, but are furnished with four anterior digits; while the American hornless forms grouped under ***Aphelops*** are distinguished by having only three anterior digits, and thereby agree with the existing species of ***Rhinoceros***. Using ***Rhinoceros*** in the wider sense indicated above, we are inclined to include ***Aphelops*** in *Aceratherium*; and we must then acknowledge that there is scarcely more than an arbitrary distinction between the latter and ***Rhinoceros***, although its retention as a genus may be advisable. The logical sequence of cutting down the genera of Prof. Cope's Rhinocerotidæ from eight to two, and the consequent relegation of his generic characters to a minor value, will be the inclusion of his Hyracodontidæ in the same family.

Extinct Cats.—The cat-like animals Prof. Cope divides into the Nimravidæ and Felidæ; the former comprising primitive generalized forms now entirely extinct, and the latter both the extinct sabre-toothed Tigers and all existing Cats. Here, again, we are afraid we must differ from the author as regards his separation of these two families, and his retention of Dr. Gray's division of the existing Cats (excluding *Cynælurus*) into several genera. The most generalized animal which can be called a "Cat" in the widest sense of the word seems to be the ***Proælurus*** of the French Phosphorites, which presents many musteline affinities, and indicates how difficult it is to form any accurate family divisions in the older mammals. From this form there is a gradual advance through the genera ***Pseudælurus***, *Archælurus*, *Ælurogale*, *Pogonodon*, etc. (most of which have more teeth than existing Cats), to the sabre-toothed Tigers and their modern allies. The sabre-toothed Tigers (which Prof. Cope divides into *Drepanodon* and *Smilodon*, but which we prefer to group together under the older name *Machærodus*) are well represented in America; and all European museums must envy the magnificent skeleton of *Machærodus* (*Smilodon*) *necator* figured in the frontispiece to this memoir. The phylogeny of the Cats, as worked out by Professor Cope and Dr. Filhol, indicates very fully the former history of the group.

Extinct Dogs.—The Dogs are included by Prof. Cope in a single family—the *Canidæ*—which has been shown by other writers to pass so imperceptibly by means of the genera *Dinocyon* and *Hyænarctos* into the *Ursidæ*, that it seems impossible to draw any distinction between the two. Prof. Cope (p. 236) recognizes eight extinct[1] American genera of the family, mainly distinguished by dental characters of more or less importance. The Miocene European genus *Amphicyon* is represented by several species; and the same may be said of the genus *Cynodictis*, which Prof. Cope identifies with *Galecynus*, Owen; the latter appearing to ourselves to be indistinguishable from *Canis*, and of later age than *Cynodictis*. The peculiar American genus *Ælurodon* appears to indicate a transition towards the Hyænoid *Ictitherium*; and since *Cynodictis* comes extremely close to some of the Viverridæ, we learn how very intimate was the former connexion between the now well-marked families of the Hyænidæ, Viverridæ, Canidæ, and Ursidæ.

The Creodonta.—The serial position of the forms included in this group have been already discussed in our preliminary remarks. Prof. Cope includes in it the Mesonychidæ (1), Hyænodontidæ (2), Chrysochloridæ (3), Centetidæ (4), Leptictidæ (5), Potamogalidæ (Mythomyidæ) (6), Talpidæ (7), Oxyænidæ (8), and Miacidæ (9). Nos. 3, 4, 6, 7, are existing families of Insectivora, the remaining five being extinct. The family Oxyænidæ includes the genera *Pterodon* and *Oxyæna*; but the former appears so closely allied to Hyænodon that we are inclined to place all three in the same family. *Oxyæna* and *Hyænodon* occur in the Lower Tertiaries of Europe and America, the latter being also represented in the higher Tertiaries of India. The type genus of the first family is *Mesonyx*—evidently a very generalized form, with the premolar and molar teeth but little differentiated from one another. Space only admits of noticing a few of the more interesting forms of the other families. The genus *Stypolophus*, Cope, is included in the Leptictidæ, and is identical with the European *Cynohyænodon*, Filhol, which Prof. Gaudry identifies with *Proviverra*, Rütimeyer—the latter name having the priority over both the others. Prof. Cope (p. 351) mentions a slight difference in the form of the fourth upper premolar of the typical *Proviverra*, but we are not inclined to regard this as of more than specific value. The author regards the Leptictidæ as the ancestral forms of the modern Centetidæ. The upper dentition of *Stypolophus* is very like that of *Pterodon*, but the lower is quite distinct, and it is compared by Dr. Filhol to that of the Opossums, while its brain is that of an Insectivore. It is probable that we may follow Prof. Huxley[2] in regarding this genus as related both to the Hyænodontidæ and the Centetidæ. Another interesting genus included by Professor Cope in the Leptictidæ is that to which he applies the name *Esthonyx*, but which has been shown in a late number of this MAGAZINE to be apparently identical with the European Eocene genus

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[1] In Prof. Cope's table *Canis* is erroneously included among the extinct genera.

[2] Proc. Zool. Soc. 1880, p. 284.

Platychœrops. The author thinks that this genus may be regarded as an ancestral form of the Erinaceidæ. The upper molars and the hinder premolars are triangular in form, and of equal complexity. In the family Miacidæ we have several genera, among which we may mention *Miacis* and *Didimictis*; this family Prof. Cope regards as making the nearest approach to the modern Carnivora Vera, the lower jaw being furnished with a true "carnassial" tooth. This approximation fully confirms our own view as to the impossibility of satisfactorily distinguishing the so-called Creodonta from the Carnivora Vera on the one side and the Insectivora on the other.

The Lemuroidea and the Insectivora.—In this memoir the author says that it appears impossible to draw any satisfactory distinction on the evidence of the skulls and teeth alone between the two groups mentioned—the latter including, it may be presumed, only those forms which the author does not class in his Creodonta. This confession appears to us to be another argument against the acceptance of the author's order Bunotheria (of which the Insectivora, as restricted by him, form a suborder); the retention of which appears to us merely to obscure the relations of its different members. In reference to Prof. Cope's so-called *Hyopsodus vicarius,*—this is a genus which in a paper read before the Geological Society on June 24th has been shown to be probably identical with the English Upper Eocene genus *Microchœrus,* whose affinities appear to be decidedly Insectivorine. Lower jaws of the genera *Notharctos* and *Tomitherium* are figured, and appear to indicate forms allied to the Lemurine *Necrolemur* and *Adapis.* A genus represented by species of small size, and named *Anaptomorphus,* is considered to be allied to the existing Lemurine *Tarsius* of Java. In the Insectivora Prof. Cope includes the European Eocene genus *Arctocyon,* on account of the form of its molars, and also classes in the same family the American *Achænodon.* With regard to the former we are fain to confess that its affinities seem so generalized that it appears to us to be impossible to assign it any very definite position, and we should have preferred to have placed it among the primitive Carnivores without indicating its relationship too closely. When, indeed, we reflect how very difficult it has been to assign living forms like *Chiromys* and *Galeopithecus,* where we have the whole animal before us, to their proper serial position, it surely cannot be expected that we can in all cases refer fossil mammals to a definite position when at the best we have only more or less perfect portions of the skeleton to guide us. *Achænodon* appears to us to be a form not improbably connecting the bunodont ungulates like *Elotherium* (with which it has been classed) with the unguiculate mammals; its affinity to the latter being indicated by the nature of the articulation of the lower jaw. We totally fail however, to see why it should be categorically referred to the Insectivora.

The Tertiary Marsupialia.—Our author divides the extinct Marsupials into the trituberculate, quadrituberculate, and multituberculate groups, from the characters of their upper molar dentition. The first is equivalent to Owen's Sarcophaga; and among it may be mentioned the European and North American Eocene genus *Peratherium,* which Prof. Gaudry identifies with *Didelphys.* The second group agrees with Owen's Poephaga, and is unrepresented in the Tertiaries of North America. The Multituberculata is divided into the Tritylodontidæ, represented by the Mesozoic *Stereognathus* of Europe and *Tritylodon* of South Africa; the Polymastodontidæ, represented by the American Eocene *Polymastodon*; and the Plagiaulacidæ, represented by the European Mesozoic *Plagiaulax* and the Eocene *Neoplagiaulax.* A genealogical table is given on page 695, in which it is sought to derive *Thylacoleo* through *Plagiaulax* from *Tritylodon*; but it appears to us that the peculiar structure of the characteristic tooth of *Plagiaulax* and its extremely small size must be an effectual bar to this view.

The Amblypoda.—We have already given our opinion in favour of regarding this so-called order as a suborder of the Ungulata; it is divided into the sections Taligrada, Pantodonta, and Dinocerata. The first is represented by the single genus *Pantolambda,* characterized by the presence of a "head" to the astragalus. The second (for which we should prefer the name Coryphodontia) includes the widely-distributed *Coryphodon Estacodon, Metalophodon, Bathmodon,* etc.; and is characterized by the presence of a third trochanter to the femur—a feature by which it is much more closely related to the *Perissodactyla* than the third section, in which it is absent. The latter section having been fully noticed in this MAGAZINE, in a review of Prof. Marsh's Dinocerata, does not call for further reference on this occasion; a number of figures of *Loxophodon* occur in it.

Permian Batrachia.—Having already exceeded the space we had originally assigned to this notice, we must pass the present memoir with the briefest reference. It contains descriptions of several forms belonging to the group called by Prof. Cope the Rhachitomi, but which we think might be more advantageously known as the Archegosauria; it being in our opinion far preferable to take group-names from the genera which have been the longest established and are the best known. The peculiar structure of the vertebral column in this group is ingeniously illustrated by the folds caused by flexure in the sleeve of a coat. Figures are given of the crania of *Trimerorhachis, Eryops,* and *Cricotus*; all of which appear to be peculiar to America. That this group had originally a very wide extension in space is proved by the occurrence of representatives in the Permian of Europe (*Actinodon* and *Archegosaurus*), in the Karoo system of South Africa (*Rhytidosteus*), and in the Gondwána system of India (*Gondwanosaurus*). All the members of the group are characterized by the imperfect ossification of the centra of the vertebral column; each of which consists of two lateral moieties, an azygos basal moiety, and in some cases of a fourth element corresponding to the "wedge-bone" of the *Rhynchocephalia.*

In the foregoing notice we have not spared adverse criticism where we thought there was cause for the same, and we venture to think that such criticism is of itself a proof of our high opinion of the work before us, and of its importance in regard to a full knowledge of the chain of Mammalian existence. We congratulate Prof. Cope on the completion of so much good work, and hope that it is but the earnest of further labours. R. L.

REPORTS AND PROCEEDINGS.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FIFTY-FIFTH MEETING, ABERDEEN, 1885.

SECTION C.—GEOLOGY.

President: Prof. J. W. JUDD, F.R.S., Sec. G.S.

Titles of Papers read September 10th—16th, 1885.

The President's Address:—On some Great Problems in Highland Geology.

H. J. Johnston-Lavis.—Report on the Volcanic Phenomena of Vesuvius.

Professor J. Milne.—Report on the Earthquake Phenomena of Japan.

Professor G. A. Lebour.—On a Slight Shock of recent Earthquake in Sunderland.

Dr. Tempest Anderson.—The Volcanoes of Auvergne illustrated by Photographs shown by the Oxyhydrogen Lantern.

Professor E. Hull.—Notice of an outline Geological Map of Lower Egypt, Arabia Petræa, and Palestine.

Professor E. Hull.—On the Cause of the Extreme Dissimilarity between the Faunas of the Red Sea and Mediterranean, notwithstanding their recent connection. (Read in Biology, Section D.)

Professor E. Hull.—On the Origin of the Fishes of the Sea of Galilee. (Read in Biology, Section D.)

Professor E. Hull.—On the Occurrence of Lower Old Red Conglomerate in the Promontory of the Fanad, North Donegal.

Professor T. G. Bonney.—On Bastite-Serpentine and Troktolite in Aberdeenshire, with a note on the Rock of the Black Dog.

Professor W. I. Macadam.—The Aberdeenshire Diatomaceous Deposits; their Extent, Chemical Composition, and Industrial Uses; with Notes on similar Deposits elsewhere in Scotland.

W. Whitaker.—List of Works on the Geology, Mineralogy, and Palæontology of Staffordshire.

Lieut.-Colonel R. L. Playfair.—On the Re-discovery of Lost Numidian Marbles in Algeria and Tunis.

C. E. De Rance and W. Topley.—Report of the Committee on the Erosion of the Sea Coasts of England and Wales.

W. Watson.—The Chasm called "The Black Rock of Kiltearn."

Rev. Dr. Davidson.—The Bass of Inverurie, a remainder of an ancient Alluvial Bed.

Dr. H. W. Crosskey.—Report of the Committee on the Erratic Blocks of England and Wales.

Professor H. Carvill Lewis.—The Direction of Glaciation as ascertained by the Shapes of the Striæ.

W. F. Stanley.—Proposed conditions to account for a former Glacial Period in Great Britain existing under similar Meteorological Conditions to those that rule at the present time.

Dr. H. Hicks.—On the Fynnon Beuno and Cae-Gwyn Bone-Caves, North Wales.

Rev. Dr. Hugh Mitchell.—Exhibition of Specimens of Fish from the Lower Old Red Sandstone of Forfarshire.

J. Gordon Phillips.—The Elgin Sandstones.

Dr. R. H. Traquair.—Preliminary Note on a new Reptile recently discovered at New Spynie, near Elgin.

J. S. Gardner.—Report on the Fossil Plants of the Tertiary and Secondary Beds of the United Kingdom.

Professor C. Lapworth.—The Great Highland Controversy; its Causes, Course, and Consequences.

B. N. Peach and *J. Horne.*—The Geology of Durness and Eriboll, with special reference to the Highland Controversy.

Professor T. G. Bonney.—Preliminary Note on some Traverses of the Crystalline District of the Central Alps.

Professor H. Carvill Lewis.—Some Examples of Pressure-Fluxion in Pennsylvania.

A. Harker.—On Slaty Cleavage and Allied Rock-structures; with special reference to the mechanical theories of their origin.

G. H. Kinahan.—On Irish Metamorphic Rocks.

John Gunn.—A Description of the Rocks of Central Caithness.

Professor A. Renard.—On some Rock Specimens from the Islands of the Fernando Nohronda Group.

Rev. E. Hill.—The Average Density of Meteorites compared with that of the Earth.

Professor Henry Drummond.—Notes on a recent examination of the Geology of East Central Africa, from the Zambesi to the Nyassa Tanganyika Plateau.

Dr. Max Schuster.—Some Results of the Crystallographic Study of Danburite.

Sir R. Owen.—American Evidences of Eocene Mammals of the "Plastic Clay" Period.

Sir R. Owen.—Exhibition of a Restoration of Tinoceras.

Professor O. C. Marsh.—Discovery of Anurous Amphibia in the Jurassic Deposits of America.

Professor T. R. Jones.—Report on the Fossil Phyllopoda of the Palæozoic Rocks.

Dr. R. H. Traquair.—On the Distribution of Fossil Fishes in the Estuarine Beds of the Carboniferous Formation.

Hugh Miller.—Some results of a detailed Survey of the old Coast-Lines near Throndhjem, Norway.

J. Melvin.—The Parallel Roads of Lochaber.

B. N. Peach and *J. Horne.*—Further Evidence of the existence of the Ice in the North Sea Basin, based on the Exploration of the Wyville-Thomson Ridge by Dr. John Murray; and on the occurrence of Shelly Boulder-clay in North Ronaldshay, found by Dr. Traill.

H. Cadell.—Recent Advances in West Lothian Geology.

Professor F. Clowes.—Barium Sulphate as a cementing material in Sandstone.

A. G. Cameron.—Notes on Fullers' Earth and its applications.

Dr. J. C. Howden.—Notes on the Glacial Deposits of Montrose.

Alex. Ross.—Notes on the Rocks of St. Kilda.

C. E. De Rance.—Report of the Committee on the Circulation of Underground Waters.

W. Whitaker.—On Deep Borings at Chatham. A Contribution to the Deep-seated Geology of the London Basin.

W. Whitaker.—On the Waterworks at Goldstone Bottom, Brighton.

CORRESPONDENCE.

FOSSIL SLUGS.

Sir,—A correspondent has inquired whether any fossil slugs are known. Having unfortunately mislaid his letter, perhaps you will kindly permit me to answer the question in your pages.

Testacella is recorded from the Middle and Upper Miocene and Pliocene.
Limax from the Lower Miocene, upwards.
Amalia from the Upper Miocene.
Parmacellina from the Upper Eocene.
Arion ater from the Pleistocene.

Vitrina, Succinea, Hyalinia are found fossil in the Tertiaries, but scarcely perhaps enter the category of "slugs," a rather vague term.

Probably many other slugs are known as fossils in America, but it is of course only genera provided with some sort of shell that can possibly leave behind any fossil remains.

7, Damer Terrace, Chelsea, *Sept.* 14, 1885. J. Starkie Gardner.

OBITUARY.

HENRI MILNE EDWARDS.

Born Oct. 23, 1800; Died July 29, 1885.

With regret we record in our present issue another loss to Science —the loss of a Naturalist who for more than sixty years devoted himself with unswerving perseverance to the unravelment of the mysterious and wondrous phenomena of animal life: and we shall not be overstepping the limits of our record by preserving in its pages a brief sketch of the work of a man who, while ranking as a chief among zoologists, carried his researches into the domain of palæontology also.

Henri Milne Edwards, though born at Bruges—on October 23, 1800—was of English parentage. His father, Lieutenant-Colonel Edwards, had settled in that city after successful operations as a *planter* in Jamaica. His mother, Elizabeth Vaux, a second wife, claimed descent from Sir Nicholas Vaux of Harrowden, first Baron Vaux. Henri was his father's twenty-seventh child. During the incarceration of Colonel Edwards in Belgium, on suspicion of aiding the escape of some prisoners, Henri was placed in the care of his eldest brother William, the eminent physiologist. Most reputations may be traced to the fostering of early inclinations, and that of Henri Milne Edwards had its incipience in a scientific analysis he essayed in his boyhood of Buffon's *Histoire des Animaux.* Educated for the medical profession, but dividing his leisure between painting and music, he took his M.B. degree at Paris in July, 1823, in which year he married Laure, daughter of Colonel Trézel. This union, which was one of affection, stimulated Edwards in the noble aims of his career. Thus early he addressed several memoirs to the Academy of Sciences, Paris, one of which, carefully elaborated with the assistance of F. Vavasseur, on the *Influence du système nerveux sur la digestion stomacale,* attracted considerable notice. It was a subject he continued later on in his mémoire, with G. Breschet, on the *phénomènes de la digestion.* Another paper printed at this dawning period (1823) deserves mention. It was his *Mémoire sur la structure élémentaire des principaux tissus organiques des animaux.* Two years later the necessities of an increasing family further stimulated his exertions. He published elementary treatises on medicine, and, conjointly with Vavasseur, the well-known *Manuel de matière médicale,* translated into the principal European languages. Edwards's passion for the study of Natural History at this time developed itself, and the numerous and admirable works which he brought out year by year threw new light on many of the problems of animal life. Hitherto, naturalists had been content to base their work on exterior characteristics, and the new and more philosophic departure inaugurated by Cuvier, namely, that in order to judge of the true relationship of animals, all their organs must be well understood, was followed up by Edwards with keenness and activity, especially in regard to modes of development; and the study of comparative anatomy and comparative physiology, *pari passu,* thus started, has been since accepted as the only true method of investigation in scientific research. Edwards may be said to have taken the lead in biological inquiry, and to have pioneered the geographical distribution of the lower forms of animal life. In order to arrive at a reasonable understanding of the plan governing the constitution of the animal kingdom he endeavoured to judge of causes by their effects; not that, for a single moment, he says, did he believe himself to be able to divine the mother-thought from which emanated the vast conception of life, nor to determine the route followed by the GREAT AUTHOR in the execution of His work. But Edwards went thus far to declare that, though he found that organisms are not really identical, the first condition imposed upon Nature in the formation of animals appears to be diversity of productions. It was his comprehensive and analytical method of exploitation constantly applied which realized the laws presiding over the organization of animated nature—laws which, put by him on a sure foundation, must be understood by naturalists of the future. Edwards's life forms a trophy of laurels won in the prosecution of these views.

In the year 1826 he commenced with J. V. Audouin a series of researches on the anatomy and zoology of animals of the coasts of France, which he visited more particularly to study living forms and to investigate habits; and before the year had expired he gave the result of these researches in a work entitled *Littoral de la France*, a great part of which, concerned with annelids, was eulogized by Cuvier. The following year, in collaboration with the same naturalist, he published the remarkable studies in experimental physiology: *Recherches anatomiques et physiologiques sur la circulation dans les crustacés*—a work which obtained in 1828 the prize for physiology given by the Academy of Sciences. By this inquiry, as declared by Cuvier, he enriched the fauna of France with new and curious species, and zoology generally with interesting observations. The results were submitted to the Academy in July and November, 1829, and they form the subject of an elaborate report presented in November, 1830, by Cuvier, Dumeril, and Latreille, in which the first idea of zones of marine life was promulgated. The great principle discovered by these researches was that, the more an animal exhibits in its organs a division of labour, the higher it is in the scale of organization; and they obtained for Edwards the credit of being the founder of the morphology of crustaceous animals. Moreover, his work became the standard authority on the group. Although in 1832 Edwards was elected Professor of Natural History at Lycée Henri IV., and at the Central School of Arts and Manufactures, he produced several popular works on natural history, among which were the *Nouveau Formulaire pratique des Hôpitaux* and the *Eléments d'histoire naturelle* of A. Comte. The latter work was reproduced to the extent of a hundred thousand copies, and was reissued in 1851 as a *Cours élémentaire de zoologie*.[1] The study of marine animals now absorbed Milne Edwards's attention. Astonished at the profusion and richness of forms yet unknown exhibited by the crustaceans in the galleries of the Musée d'Histoire Naturelle, he resolved to write a complete history of these animals. His work, printed in the years 1834—1840, and entitled *Histoire Naturelle des Crustacés* (3 vols. and atlas), bears on every page evidence of the author's remarkable powers of observation, as does also his article "Crustacea," contributed in this interval to Todd's Cyclopædia. A visit to the coasts of Algeria was undertaken in 1836, and the materials then collected were given to the scientific world in a series of memoirs styled *Recherches anatomiques et zoologiques sur les polypes*, one marked result being the separation of the polyzoa from the polyps, included together in the group of Radiata founded by Cuvier. The importance, number, and variety of his works had already surprised zoologists, and on the death of Cuvier, in 1838,

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[1] This work was also translated into English by Dr. R. Knox (London 1856) and had a very large sale in this country. Many other copies of the work *not bearing Milne Edwards's name*, have been published "by English, Scotch, Irish, and American literary contrabandists."—(Knox).

Edwards was selected to succeed him in the Academy of Sciences in the Departments of Anatomy and Zoology.

The *Notice* of his works on this occasion included a résumé of sixty-six original memoirs, apart from numerous articles inserted in the *Dictionnaire Classique d'Histoire Naturelle,* and other similar publications. In this same year Edwards began the superintendence of the new edition of Lamarck's *Histoire Naturelle des non-vertébrés,* continued to 1845; and he was now charged with the class of anatomy and comparative physiology until then under the direction of Geoffroy Saint-Hilaire. These appointments, however, do not appear to have interfered with the progress of his special pursuits. In 1839, after further researches on the Coasts of la Manche, etc., continued the year following at Nice, he published, in a series of memoirs, the facts which he had gathered concerning the embryology and comparative anatomy of the Ascidians. Herein he gave the first definite account of the mode of reproduction by budding. The development of beings which before had never been utilized in the comparative study of animals appeared to him to constitute a subject of the highest value; and his speculations show how great a part embryology plays in zoological science. In 1841 he succeeded his friend J. V. Audouin as Professor of Entomology at the Museum of the Faculty of Sciences. Bent on making progress with the study of marine animals, Edwards conceived the idea of dredging up specimens from the bottom of the sea, particularly at great depths, and of bringing to light a submarine world of animal existence then unknown. The appliances for dredging were at that time of a primitive description, and he did not hesitate to risk his life in diving operations. This happened on the coast of Sicily, during a voyage undertaken in company with A. de Quatrefages and E. Blanchard. The results were considerable, and were explained in the work, *Recherches anatomiques et zoologiques faites pendant un voyage sur les côtes de la Sicile.* They form a splendid quarto volume of over 850 pages, illustrated with nearly 100 coloured plates. The work is for the most part a corrected report of the series of memoirs contributed to the *Annales des sciences naturelles.* On his return in 1844, Edwards was nominated Professor of Comparative Physiology to the Faculty of Sciences of Paris, and five years later he undertook the functions of Dean of the Sorbonne, an office which he held to the day of his death. The superintendence of the removal of the laboratories was a task which Milne Edwards successfully accomplished, to the great advantage of future students. In April, 1847, he was created an officer of the Legion of Honour, and was promoted, August 31, 1861, to the rank of a commander.

Jointly with Jules Haime, Milne Edwards published in the Palæontographical Society's volumes for 1850–54 a *Monograph of the British Fossil Corals,* and the next year a *Monographie des Polypiers fossiles,* both subjects being treated in a masterly manner, and forming a most solid contribution to palæontological knowledge. The year succeeding Edwards produced another long memoir—on the *Morphology of Crustacea;* and very shortly after his work on the *Tendances de la Nature*, in which he gave forth his opinions on the vitality of different parts of organisms. We have additional evidence of the versatility of his genius about this period in further *Recherches sur les polypiers* (eight memoirs, with Haime, 1848), a paper on the *mœurs de divers insects xylophages* (1848), and a report on *pisciculture* (1850). Elected an Associate, in 1854, of the Academy of Medicine, in 1856 he visited London to receive from the Royal Society the Copley Medal, in presenting which the President declared that it would be a difficult task to name any one existing naturalist who had prosecuted his researches with success over so wide a range of investigation. On the death of Haime, in that same year, Edwards completed the *Histoire naturelle des Coralliaires ou Polypes*, 3 vols. and atlas. On the 28th May, 1862, he succeeded Isidore Geoffroy Saint-Hilaire as Professor of Zoology at the Musée, of which shortly after he became Assistant-Director. In 1867 appeared his *Rapport sur les progrès récents des sciences zoologiques en France*. The *Leçons sur la physiologie et l'anatomie de l'Homme et des Animaux* were published between 1857 and 1881, in fourteen volumes. They were dedicated to his relative M. J. Dumas, and will always possess importance for the student from the immense amount of details, accompanied by copious references to the labours of others, which they contain in limited compass. On the appearance of the last volume, a portrait-medal of the author was struck by his pupils and admirers; at the same time the Society of Sciences of Holland designated him as the recipient of the Boerhave Medal, given for the most valuable works in Natural History. Various learned societies had enrolled Edwards among their members. Crowned with the honour and success of a long life devoted to the advancement of science, Henri Milne Edwards died at Paris on the 29th of July of the present year. The wide range of his knowledge of zoology has rarely been equalled; and it must be borne in mind that he laboured when the study of zoology was scarcely settled on a scientific basis. A glance at the Royal Society's catalogue of papers to 1868 will at once be convincing in regard to his work; 106 papers are placed to his credit alone, while thirty appear in connection with other well-known men of science. Generation, changes of form, mode of growth, mechanism of respiration, forms of blood-corpuscles, the nervous system, circulatory apparatus, geographical distribution, are among the subjects treated in the side-walks as we may term them of his career.

Personally, Milne Edwards was of a delicate constitution, and the interest excited by his discoveries may be said to have prolonged his life to the advanced age he reached. He was a good linguist, his English and French being perfect. His love for France and its people displayed itself in many instances of bravery and self-sacrifice during the cholera epidemic of 1832 and the Franco-German war which broke out in 1870. His rare qualities and generous nature will be missed by many a student and confrère, while the scientific world will mourn the loss of the remarkable powers of elucidation and classification evidenced by his life-long labours.—T.N.

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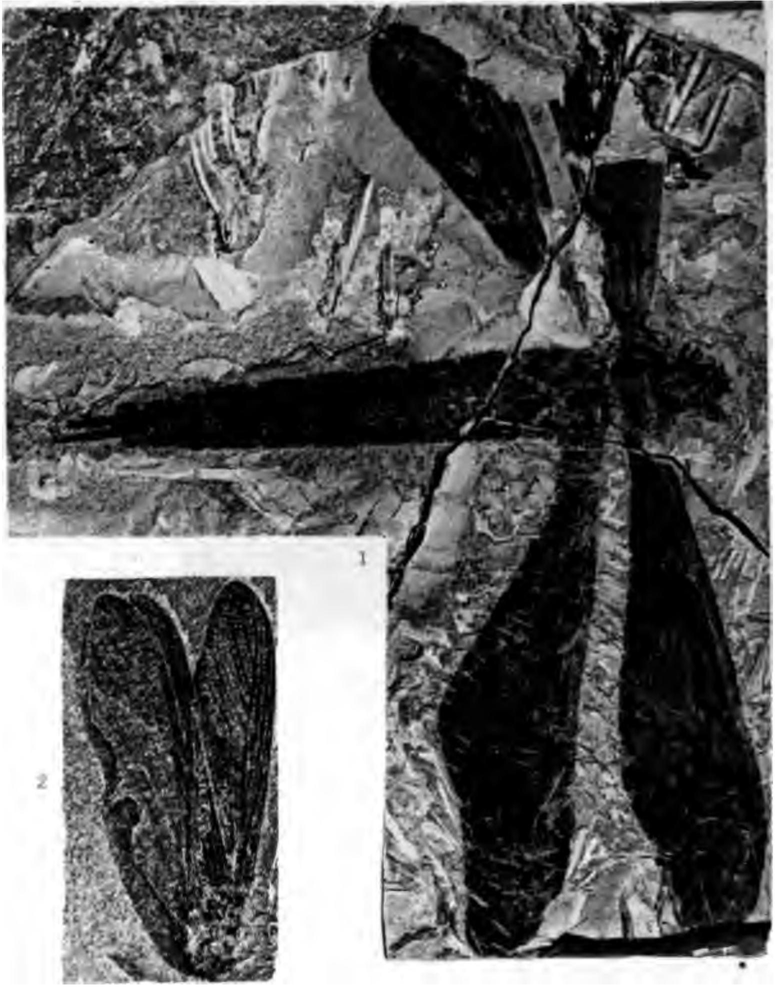

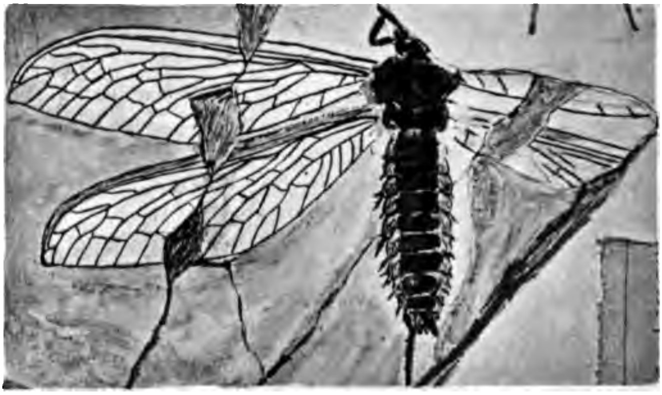

1. WOODWARDIA NIGRA. 2. CALONEURA DAWSONI.

3. CORYDALOIDES SCUDDERI.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. II.

No. XI.—NOVEMBER, 1885.

ORIGINAL ARTICLES.

I.—THE FOSSIL INSECTS OF THE PRIMARY ROCKS: A RAPID SURVEY OF THE ENTOMOLOGICAL FAUNA OF THE PALÆOZOIC PERIOD.[1]

By CHARLES BRONGNIART,
Honorary and Corresponding Member of the Manchester Geological Society.

(PLATE XII.)

THE fossil insects of Palæozoic times are but little known, in consequence of the small number of specimens which have been discovered in the various Carboniferous deposits of the globe.

Moreover, these specimens are usually imperfect, and authors generally have had at their disposal only fragments of wings, the soft parts of the body having probably been decomposed, leaving no trace in the shales.

The rarity and the imperfection of the specimens are the principal causes why so few naturalists have taken up the study of the fossil Hexapoda.

The important discoveries, however, made since 1878, in the mines of Commentry (Allier)—thanks to the devotion of the enlightened Director of these mines, M. Henry Fayol—have resulted in giving us more exact notions of the Insect fauna of the Coal Period.

Whilst in Europe and North America there have been described only about 120 examples, at Commentry, since 1878, 1300 have been met with, of which the greater part is admirably preserved. Up to the time of these discoveries no idea of the form of the body of these Coal-insects could be given; but I am now in a position to make known the external anatomical details of the bodies of these witnesses of bygone ages.

The wings of insects furnish valuable information to aid in their determination, but one must not always rely solely on their form and neuration, for it would often result in the commission of grave errors.

It is necessary, as much as possible, to take into account the characters of the body. Many authors, having had at their command only wings, or fragments of wings, have sometimes been deceived in their determinations. Moreover, it has been too long thought possible that the divisions created to classify living insects could be made to include all fossil insects.

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[1] Translated and read before the Manchester Geological Society, October 6th, 1885, by Mark Stirrup, F.G.S., Hon. Sec. Revised and reprinted by permission of the author and translator. With a plate, from the Bulletin de la Société des Amis des Sciences Naturelles de Rouen (année 1885, 1er semestre).

It is curious to find how little these insects have changed, and to see that creatures, which are reckoned among the most ancient, have undergone modifications of only a secondary order, in coming down from the Coal period to the present time.

Nevertheless, there is more homogeneity among the primary Hexapods than is presented by this group to-day, but this need not astonish us.

The insects which are found in the Palæozoic shales belong to types represented at the present day by the Orthoptera, the Neuroptera and the Hemiptera.

Some authors have announced the discovery of Coleoptera; but these so-called Coleoptera are really fossil fruits or parts of Arachnida (?).

I have, myself, considered the perforations found in some fossil wood to have been the work of Coleopterous insects; but if that were so, Coleoptera, which have hard elytra, would surely have left their impressions on the shales.

The presence of Coleoptera in these Palæozoic deposits seems to me then very doubtful, and one can only assume as certain the existence of Hemiptera, Orthoptera and Neuroptera.

But the limits of the two latter orders have been very differently estimated by various authors, some not considering the classification as a natural one, and are therefore inclined to unite them in a single group. This would, in my opinion, be going too far. The existing Orthoptera are well characterized as much by the general form of the body as by the neuration of their wings, and by their incomplete metamorphoses.

The Physopoda, the Corrodentia, and the Amphibiotica, have, with good reason, been united to the Orthoptera properly so called, under the denomination of Orthoptera pseudo-Neuroptera. The latter (Orthoptera pseudo-Neuroptera) would have been placed a long time ago among the Neuroptera, but their incomplete metamorphoses ranged them rather with the Orthoptera.

The true Neuroptera are then the Planipennia and the Trichoptera, which have complete metamorphoses. The members of the latter sub-order may serve as links to unite them with the Lepidoptera, as much on account of the neuration of their wings and of the scales or hairs which cover them, as for the buccal apparatus, which forms a sort of proboscis by the union of the jaws and of the lower lip, the mandibles being atrophied.

Among the Hemiptera, the Homoptera or Cicadidæ are the insects with incomplete metamorphoses. Some naturalists have wished to divide insects into two great groups—those which have incomplete, and those which have complete metamorphoses. It is easy to prove the defect of this classification from the indications mentioned previously. In fact, it would be compulsory to sunder the Neuroptera (Planipennia and Trichoptera) from the Orthoptera pseudo-Neuroptera, insects which are in reality very closely allied. For analogous reasons, one is obliged to abandon the division into Mandibulata and Haustellata.

In 1863 Dr. A. S. Packard, jun., proposed to create two series among the insects: the METABOLA and the HETEROMETABOLA. In this latter group he ranges the Coleoptera, Orthoptera, Neuroptera, and Hemiptera; bringing into the first group the Hymenoptera, Diptera, and Lepidoptera.

Mr. Samuel H. Scudder had the same idea in this respect as Packard; he created the names of Sternoptena (Metabola of Packard) and of Gastroptena (Heterometabola of Packard). But the terms employed by Packard seemed to him better fitted for general use, and he has adopted them.

Packard and Scudder start upon the principle that the more an Arthropod has the three regions of the body (head, thorax, and abdomen) clearly distinct, the one from the other, the more it is raised in organization. It is among the Hexapoda that this character is most prominent: the Myriopoda, on the contrary, being the most degraded in consequence of the great number of segments of which the body is composed. The higher Crustacea and the Arachnida are intermediate examples, for the head and the thorax are united, and form the Cephalothorax. Among insects the component parts of the thorax are more or less united together among themselves, and those types whose thoracic segments are most united, and, consequently, whose organs of flight are most nearly connected, must be considered the most perfect.

The METABOLA are the Hexapoda which present this perfection in the highest degree. They form unquestionably a more homogeneous section than the HETEROMETABOLA, and are, moreover, of more recent appearance on the surface of the globe.

Let us then briefly state the principal characters of these two great groups of insects, as Packard and Scudder have described them:—

METABOLA.	HETEROMETABOLA.
Body clearly divided into three very distinct parts (head, thorax, abdomen), the three segments of the thorax closely united together.	Body divided into three parts; the three segments of the thorax are very distinct.
Component pieces of the mouth arranged, as a whole or in part, for suction.	Mouth arranged generally for masticating, rarely for sucking.
Mandibles rarely opposed one to the other.	Mandibles opposite one another.
Anterior wings membranaceous and much larger than the posterior, which are sometimes rudimentary.	Anterior wings more or less coriaceous, with very numerous and strong nervures, generally longer and straighter than the posterior wings, or equal to them.
Larva generally soft, not resembling the adult.	Larva most frequently resembling the adult.
Pupa always inactive.	Pupa active or inactive.
Complete metamorphosis.	Metamorphosis most frequently incomplete.
Lepidoptera—Diptera—Hymenoptera.	Hemiptera—Neuroptera—Orthoptera.

It will be remarked that I have omitted to mention the Coleoptera, which Scudder places among the Heterometabola; but in my opinion, the Coleoptera form an intermediate group, or are, at least, among the Heterometabola, in course of progression towards the Metabola.

In the Palæozoic rocks the presence of Coleoptera is, as already remarked, very problematical, and the orders, whose existence has been proved, all belong to the great section of the Heterometabola. The classification of MM. Packard and Scudder is therefore that which agrees best with the evidence afforded by palæontology, embryology, and morphology.

We proceed now to pass in review the Heterometabola found in the Palæozoic formations, showing the relationships which they offer to the present fauna.

SILURIAN SYSTEM.—An insect was found this year in the sandstone of Jurques (Calvados) analogous to the May-Hill-Sandstone belonging to the Middle Silurian. On Nov. 12, 1884, MM. Thorell and Lindström announced the discovery of a Scorpion (*Palæophonus nuncius*) in the Upper Silurian of the island of Gotland. Almost at the same time a second Scorpion was discovered in Scotland in similar deposits.[1] The impression on the Jurques sandstone consists of a wing whose neuration recalls that of certain Orthoptera of the families of the Acrididæ, Locustidæ, and especially of the Blattidæ.

That which is very remarkable, and which distinguishes this impression from all the wings of living or fossil *Blattæ*, is the length of the anal nervure and the small width of the axillary field. Pending new discoveries which may enlighten us concerning the zoological affinities of this fossil, we have placed it in the family of the Blattidæ, under the name of *Palæoblattina Douvillei.*

DEVONIAN SYSTEM.—Several remains of wings have been found in the Devonian shales of New Brunswick; they have been studied with care by Mr. Scudder, who has referred them to the Neuroptera or to the Orthoptera pseudo-Neuroptera.[2]

The estimate of the affinities of these insects is very difficult, and Mr. Hagen has blamed Mr. Scudder's mistakes in his determinations. Without wishing to detract from the importance and excellence of Mr. Scudder's work, we consider that this naturalist has been a little too hasty in his conclusions, and that his determinations are at least a little risky, having regard to the bad state of preservation of his material. Nevertheless, Mr. Hagen has, in our opinion, wandered much further from the truth than Mr. Scudder.

1. *Gerephemera simplex.*—Scudder, who had created the family of the Atocina for this fossil imprint, has placed it in my group of the Protophasmida. Is it right or wrong? It seems impossible to say, for it appears to me difficult to form a correct opinion from so small a fragment. This wing must have belonged to a large insect; it was about 6 centimètres long. The wing was rather elongated, and the nervures were united by a rather loose reticulation.

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[1] Mr. R. P. Whitfield (under date July 31st, 1885) announced in "Science," vol. vi. No. 130, pp. 87-88, the discovery of a Scorpion in the Waterlime group, Lower Helderberg, of Oneida County, N.Y., nearly on the same geological horizon and closely agreeing with the Swedish fossil. A figure is also given of the specimen.

[2] See GEOLOGICAL MAGAZINE, 1868, Vol. V. pp. 172, 216.

2. *Platephemera antiqua.*—It is with reason that Scudder placed this wing in the family of the Ephemeridæ; Hagen is mistaken in wishing to refer it to the Odonata. This wing reminds one much of that of *Palingenia virgo;* but the fossil is seven times larger than the latter.

3. *Lithentomum Hartii.*—The remains of a wing thus named by Scudder are considered by that author as belonging to a neuropterous insect of the group of the *Sialina.* He creates for it the family of the Cronicosialina. So much trouble appears to me useless, the specimen not being, in my opinion, sufficiently well preserved, to permit the appraising of the characters of this fossil.

4. *Homothetus fossilis.*—The wing that Scudder describes under this name presents characters common to the Neuroptera and the Orthoptera. He creates the family of the Homothetidæ for it.

I have been able to compare the figure given by Scudder with some insects from Commentry, and am convinced that this type is near to the Ephemeridæ (genera *Ephemera* and *Potamanthus*).

5. *Dyscritus vetustus.*—In spite of the smallness of the fragment represented, it ought, in my opinion, to be classed in the same family (Ephemeridæ or Homothetidæ).

6. *Xenoneura antiquorum.*—The imprint which the author describes is curious, because it presents at the base of the wing some striæ, which have induced a belief in an apparatus of stridulation.

Scudder, having regard to the absence of reticulation between the widely separated nervures, thinks that this insect forms a special and extinct family in the order of the Neuroptera. I am much of his opinion with respect to all these Devonian insect remains; but I believe that in the present state of our knowledge it is impossible to be quite certain; we must wait further discoveries. Nevertheless, if Mr. Scudder's opinions are to be accepted, one must believe that the Neuroptera, the Neurorthoptera, and Orthoptera pseudo-Neuroptera were already in existence during the Devonian epoch.

Carboniferous System.—It is in this system that we begin to find a pretty large variety of insects, and, thanks to the grand discoveries made at Commentry, we are able to establish a little order in this very interesting subject of the Palæozoic Hexapoda.

The number of works published on these insects is already considerable, and we owe much to MM. Germar, Goldenberg, Geinitz, Sterzel, Van Beneden, Dana, Lacoe, Woodward, Andree, Goss, and, above all, to Scudder, for having studied with patience and perseverance the materials that they have had in their hands.

But as the number of the fossil remains that they have made known was relatively small, it has been very difficult for them to give a comprehensive view of the entomological fauna of these ancient times.

This task has been for me an easier one, seeing that I have had at my disposal a series of well-preserved and numerous specimens.

I am therefore about to sketch out a Prodromus of the Hexapoda of the Coal epoch.

1. Orthoptera.—Claus places the Thysanura among the Ortho-

ptera; they are generally considered as being a primordial type of insects. No author has described them as occurring in the system with which we are now engaged. Nevertheless they existed as early as the Carboniferous period, for 45 specimens have been found at Commentry.

It is difficult to see the number of the joints of the legs, of the palpi and of the antennæ; but these organs can be discerned upon several specimens.

The body is cylindrical, becoming thinner at the posterior part, and terminated by a multi-articulate filament as long as the body.

The antennæ and the legs are thick and short, the head is rather large. The prothorax is very narrow, the mesothorax and the metathorax are co-equal and much longer than the prothorax.

The segments of the abdomen are ten in number and equal in size, the last only being a little longer than the rest.

It appears to me that upon one of the specimens some abdominal plates are seen, as has been observed on *Machilis.*

The whole of the body (antennæ, legs, thorax, abdomen) is covered with very numerous and very short hairs. The body with the abdominal filament varies in length between 15 and 22 millimètres.

This insect resembles *Lepisma* and *Machilis.* It differs from them in several characters, but the principal difference consists in the presence of a single abdominal filament in the fossil species. I shall designate this ancestor of the living Thysanura by the name of *Dasyleptus Lucasi*, dedicating it to M. H. Lucas, of the Paris Museum.

Among the Orthoptera a great number of Blattæ or of Palæoblattariæ (Scudder) have been described. and Mr. Scudder has classed them in several groups. As he has made a special study of them, it is not necessary to speak of them here.

Goldenberg has named a wing *Fulgorina Klieveri*, which must have belonged to a large Blatta; we shall designate it by the name of *Megablattina Klieveri.*

Another family of Orthoptera was pretty well represented, which I propose to call Palæacridiodea. The first group contains many genera; the *Œdischia* (mihi), of which the third pair of legs resemble those of living locusts. The *Sthenaropoda* (mihi), near allies of *Œdischia,* but whose legs are thicker and shorter, and less fitted for leaping.

The genus *Protogryllacris* (mihi), represented by an insect called *Corydalis*, then *Gryllacris*, and afterwards *Lithosialis*, ought to be changed in order to show that this insect did not resemble *Sialis.*

A fourth genus, *Paolia* (Scudder), including many species, should be included in this first group.

The second group contains three genera, namely:—

Sthenarocera (mihi), insects with strong and long antennæ, short body, and thick, long legs, and long and narrow wings, recalling somewhat those of the *Pachytylus.* These insects measure fully 11 centimètres from the anterior part of the head to the extremity of the wings, when the latter are folded upon the back.

Caloneura (mihi) is nearly related to the foregoing; but the legs and the antennæ are more slender, the wings are shorter and not so narrow; the nervures are admirably surrounded by coloured bands. See *Caloneura Dawsonii* (Plate XII. Fig. 2).

Macrophlebium Holleberi of Goldenberg goes into this family for the present. All these insects may be regarded as the ancestral type of the Orthoptera-Saltatoria of the present day.

I propose to form the order NEURORTHOPTERA, to include two sub-orders—that of Neurorthoptera properly so called, and that of Palæodictyoptera (Goldenberg).

The first sub-order will comprise—

1. The family of the Protophasmida (mihi), represented by the genera *Protophasma* (mihi), *Lithophasma*, which I create for a wing figured by Goldenberg under the name of *Gryllacris lithantraca*, and which afterwards Scudder had placed in the genus *Lithosialis;* lastly, the genus *Titanophasma* (mihi), of which *the body only* is known to us, a gigantic body measuring 28 centimètres in length; also the genus *Archegogryllus* (*A. priscus*, Scudder).

2. The family of the Sthenaropterida, which includes *Meganeura Monyi*, a wing measuring 33 centimètres in length—I had named it *Dictyoneura Monyi; Archæoptilus ingens* (Scudder), and *A. Lucasi* (mihi), wings which must have attained 25 to 30 centimètres in length.

Then *Megathentomum pustulatum* of Goldenberg will take its place in this family; two insects that Goldenberg had named *Acridites formosus* and *A. carbonatus* will also come into the genus *Megathentomum.*

In the first sub-order of the Neurorthoptera I have placed some insects of large size, whose wings have strong nervures united by a rather loose reticulation, insects which have some likeness to our living Phasmians by the form of the body, but which are much removed from them by the neuration of their wings. We must consider the Phasmians as much modified descendants of these ancient types.

The second sub-order has been created by Goldenberg, and has been adopted by other authors. This savant, nevertheless, had elevated it to the rank of an order. It contains a series of insects of rather large size, which seem to have completely disappeared from our present fauna.

The first family, that of the Stenodictyopterida, is composed of insects which have a thick and short, but broad body, short legs of moderate length. But that which rightly characterizes them, and makes of them a sufficiently homogeneous group, is the reticulation of the wings. The latter are elongate, rather narrow, traversed by rather straight nervures united by a very regular network of great fineness, reminding one a little of the network of the wings of our living *Odonata.*

This family contains six genera, namely:—

1. The genus *Eugereon* of Goldenberg (*Eugereon Boeckingii*, Gold., *E. Heeri*, mihi) is characterized by a short and thick but broad body; the head is small, the prothorax is scarcely broader than the

head, whilst the mesothorax and the metathorax are much broader and longer. The legs are short and thick, and seem to be furnished with spines. As to those special organs which Goldenberg has described near to the mouth of the insect, I have not been able to find them on my specimens, which are notwithstanding very well preserved. On the other hand, the abdomen bears at its extremity two recurved appendices.

2. The genus *Scudderia* (mihi) is proposed for an insect whose neuration is different from that of *Eugereon*, and which is of larger size, the wing measuring nine centimètres in length.

3. I have given the name of *Megaptilus Blanchardi* to the large wing that I previously supposed must have belonged to *Titanophasma Fayoli*. Its neuration recalls that of *Eugereon* and of *Scudderia*. It must have measured 18 to 20 centimètres in length and five centimètres in breadth. Therefore it must have been borne by an insect of considerable size.

4. *Haplophlebium Barnesii* and *H. longipennis* of Scudder will take their place here.

5. Then will come *Goldenbergia* of Scudder and *Dictyoneura* of Goldenberg.

I place in the genus *Goldenbergia* the following species:—

Termes Heeri, Goldenberg.
,, *affinis*, ,,
,, *laxus*, ,,
,, *contusa*, Scudder.
,, *longitudinalis*, ,,
Termitidium amissum, Goldenberg.
Dictyoneura Decheni, ,,

Dictyoneura Humboldtiana, Goldenberg.
,, *anthracophila*, ,,
,, *elegans*, ,,
,, *elongata*, ,,
,, *Smitzii*, ,,
,, *obsoleta*, ,,
,, *sinuosa*, Scudder.

The genus *Dictyoneura*, Goldenberg, will comprehend the *D. Goldenbergi* (mihi), *D. libelluloides*, Gold., *D. jucunda* (Scudder).

The body is short and thick, the head large, the thorax has the three segments nearly equal and much raised, nevertheless the prothorax is narrower. The abdomen measures 45 millimètres in length, and is terminated by two long multi-articulate filaments, and by two recurved hooks; moreover, some foliaceous appendages are observed, borne by the antepenultimate ring. The legs are short, strong, angular, and spined. The wings are not very wide (25 mm.), and have a very distinctive neuration. The reticulation recalls that of the preceding genera; the wings were traversed by coloured bands.

The second family, that of the Hadrobrachypoda (mihi), comprises two genera, the *Miamia* (Scudder) (*M. Bronsoni*) and the *Leptoneura* (mihi), *L. Oustaleti*, *L. delicatula*, *L. robusta*, *L. elongata* (mihi).

All these insects have a very distinctive *facies*. They somewhat resemble the living *Termes*, but, nevertheless, they cannot be ranged in the same group. It would not appear to me an exaggeration to say that they are ancestral types of *Termes*.

The head is pretty broad, armed with strong mandibles, the antennæ are short, the legs are short and squat, the wings are elongated, a little sickle-shaped, and traversed by fine nervures. Some wings are still tinted by a rather clear brown pigment.

The third family of these Palæodictyoptera includes some insects absolutely new; I shall designate the family by the name of Platypterida.

The wings are broad, generally rounded at their extremity, resembling, morphologically speaking, the wings of the Protophasmida, but differing from them completely by the neuration; the nervures, in fact, are rather separated one from the other, and the wings are coloured by pigments often forming very elegant outlines. The body is less blunt than that of the preceding insects, and the abdomen is terminated, in one of the types, by two filaments.

This family will comprise four genera, namely:—1. *Lamproptilia* (*L. Grand'Euryi*, *L. priscotincta*, *L. elegans*, mihi). 2. *Zeilleria*; *Z. fusca*, *Z. formosa*, *Z. carbonaria* (mihi). 3. *Spilaptera*; *S. Packardi*, *S. venusta*, *S. libelluloides* (mihi). 4. *Acridites priscus* (Andree).

Afterwards comes a series of insects which may be included in the order of the *Pseudo-Neuroptera*; six families may, in the present state of our knowledge, take their place in this order.

1. The family of the Megasecopterida, mihi (in which I have placed eight genera), is characterized by insects with a body more or less robust, with a head generally small, with legs of middle size, with an abdomen terminated by two long appendices, which appear to be multi-articulate and hairy, with wings nearly similar to one another, rather elongated and narrowed at their base, showing nervures much separated from one another, and united by large nervures, which gives them a very special *facies*. The abdomen sometimes presents lateral plates which must have served for respiration.

The genera *Protocapnia*, C. Brong., *Brodia* (*Br. priscotincta*), Scudder, *Trichaptum*, C. Brong. *Campyloptera*, C. Brong., will be classed in this group. The wings of these insects are generally coloured by rather irregularly disposed spots.

The genus *Sphecoptora* (mihi) comprises insects with very slender wings, extremely pedunculated, very narrow, and of a deep tint, ornamented with little circles deprived of colour, and rather irregularly arranged.

Here I think should be placed the *Breyeria Borinensis*, described by M. Preudhomme de Borre.

The genus *Woodwardia* (mihi) is a very interesting one; it includes three specific types—*W. modesta*, *W. nigra* (Plate XII. Fig. 1), and *W. longicauda*. These two last are remarkably well preserved; the head is rather small, and very distinct from the thoracic rings. The prothorax is shorter than the two other rings. The abdomen, composed of ten rings, is slightly cylindrical, narrower at its extremity, and terminated by two long filaments. The wings are triangular, and, as they are very elongated, they present an obtuse angle nearly in the middle of the wing. The wings are of a deep colour, and present here and there little rounded spots of a brighter shade.

The body of *W. nigra* is 8 centimètres in length, without counting the filaments, which are from 10 to 12 centimètres long. The breadth of the fully-extended wings is at least 16 centimètres.

It is here that I propose to place the genus Corydaloides (mihi), *C. Scudderi* (Plate XII. Fig. 3), *C. gracilis*, created for some insects of the smallest size, but whose body measures 4 to 5 centimètres in length; the spread of the fully-extended wings is about one décimètre; the body is more blunt than that of the *Woodwardia*, it is also less cylindrical. The neuration is analogous to that of the preceding genus; the nervures and nervules are nevertheless more abundant, and the wings are not coloured.

But this genus presents a very curious peculiarity upon which it is well to insist. Firstly, I would remind you that insects breathe by the aid of tracheæ, whose distribution in the body is variable. Among perfect insects these tracheæ open externally by orifices which are called stigmata; these generally breathe the ordinary atmospheric air.

A great number of larvæ, especially those of the Neuroptera and of the Orthoptera, are aquatic, and the organs of respiration are modified. The tracheæ, in place of ending suddenly and presenting openings or *stigmata*, ramify endlessly. Sometimes the extremities of the tracheæ are free, at other times they are united in some kind of foliaceous organs. The insect then breathes the air contained in a state of mechanical solution in the water, either by the aid of branchial tufts, or by the means of branchial plates.

Among the larvæ of the Ephemera the first seven rings of the abdomen show on each side a foliaceous organ, in which the tracheæ are seen to ramify. The oscillations of these appendages maintain a continuous current around the larvæ; these organs are only lost at the time of passage to the state of the sub-imago.

In 1848 Newport made known a pseudo-Neuropterous insect of the family Perlidæ, the *Pteronarcys regalis*, which presents in the adult state, on the under part of the abdominal rings, some branchial tufts protected by a sort of pocket, and besides which it is provided with stigmata. This insect is amphibious, it can breathe the ordinary atmospheric air and the air which is contained in mechanical solution in the water.

The *Corydaloides* (mihi) offers in the adult state an analogous disposition of the organs of respiration. Each one of the abdominal rings presents a plate on each side, where one can distinctly see, even with the naked eye, the branching out of the tracheæ. I have, besides, been able to verify the presence of stigmata. I possess ten impressions of this genus.

It is then permissible to suppose that these insects were amphibious like the *Pteronarcys*. Like the latter, it presents at the extremity of the abdomen two multi-articulate filaments.

I shall place by the side of these Megasecopterida an ancestral type of the Libellulæ; for which the creation of the family Protodonata and the genus *Protagrion* seems to me necessary. At present only a single wing has been found at Commentry. It measures 10 centimètres in length and two in breadth. Its form, its neuration, and its reticulations remind one much of the living Odonata. There are, nevertheless, some rather notable differences.

The third family, that of the Homothetida of Scudder, contains some insects of more modest size, slenderer bodies, more sessile wings, and with finer neuration. The nervules are also more numerous than in the Megasecopterida. In this family will be classed the *Hemeristia occidentalis* (Scudder), the *Pachytylopsis Persenairei* (P. de Borre), the *Chrestotes* (*C. lapidea*, Scudder); *C. Danae*, Scud. (=*Miamia Danae*, Scud.); *C. lugauensis*, Sterzel; *Omalia macroptera* (Cœmans and Van Beneden); lastly, three new genera from Commentry (*Oustaletia*, *Brachyptilus* and *Diaphanoptera*).

The last three families of this group include some ancestral types of the Ephemeridæ, Perlidæ, and of the Ascalaphæ. The Protephemerina (genus *Homaloneura* (mihi) near to the living *Potamanthus*). The Protoperlida (genera, *Protodiamphipnoa* (mihi); *Protokollaria* (mihi); *Pictetia* (mihi); *Protoperla* (mihi).) The Protomyrmeleonida (genus *Protascalaphus* (mihi).)

The order of the Hemiptera is represented during the Palæozoic epoch. Up to the present time there have only been met with those types which we have been able to class in the group of the *Homoptera*; these are the ancestors of our Fulgoridæ and of our living Cicadidæ. Goldenberg has named *Fulgorina Ebersi* and *Fulgorina lebachensis*, insects very near to our *Fulgora*. In this same genus I place some insects from Commentry, *F. Goldendergi* (mihi), *F. ovalis* (mihi), and *F. minor* (mihi).

The creation of several generic sections is necessary in order to denote some remarkable specimens that I have received from Commentry, namely:—

Rhipidioptera elegans (mihi).
Dictyocicada antiqua (mihi).
Protociccus parvulus and *P. fuscus* (mihi).
Palæocixius Fayoli, & *P. antiquus* (mihi).

Mr. Scudder names a wing *Phthanocoris occidentalis* that he considers as belonging to a Hemiptera-Heteroptera. I do not share his opinion, and I find a great analogy in the neuration between this wing and those of *Pœocera olivacea* (Blanchard), which belong to the Homoptera.

This communication may be considered as giving a general view of the fauna of the primary Hexapoda. New discoveries will perhaps compel naturalists to multiply genera, but I believe that the general sections here indicated will be able to be retained; for all that I have stated is based upon the numerous discoveries made at Commentry during the last eight years. These discoveries have enabled me to rectify many mistakes occasioned by want of precise data, and well-preserved specimens. It is far from being perfect, but it may prove of service, if it only affords a glance at the riches which have been supplied to me by the mines of Commentry.

At the moment of going to press I am in receipt of a new memoir from Mr. Scudder, which establishes some new families and genera among the primary Hexapods.

Although differing in some cases, we are agreed upon many points. The new genera which he creates demand a close examination, which I reserve for another occasion; but it is curious to note how few types Mr. Scudder has found in America similar to those which have been described in Europe.

II.—ON THE GENUS *GALERITES* = *ECHINOCONUS*.

By Prof. P. MARTIN DUNCAN, F.R.S., etc.

IN my former communication to the GEOLOGICAL MAGAZINE[1] on *Galerites albogalerus*, I gave the results of the examination of the specimens in the British Museum and of many others, and stated that the species was edentulous, and that a true fifth basal (posterior generative plate) was never present. I explained that the so-called jaws were ten buccal plates, that the so-called auricles were raised surfaces in casts, and therefore depressions in the real, and that Cotteau, who had noticed a fifth plate, stated it was exceptional. This fifth plate is absolutely a part of basal plate No. 4 (left posterior generative), and is not a true basal plate.

Before the paper was sent to the GEOLOGICAL MAGAZINE, M. Cotteau had published a "Description des Échinides fossiles de l'île de Cuba," in the Ann. de la Soc. Géol. de Belge. t. ix. Mémoires. Some months since I saw this interesting and beautifully illustrated paper for the first time, thanks to the distinguished author.

I regret that I did not see this paper before I wrote the communication on *Galerites*, not that it interferes with the statements made therein, but because it appears discourteous not to have noticed and considered the interesting paper about the Cuban fossils. Moreover, had I seen the paper, there were facts in it which would have required very careful notice.

I regret the matter all the more because Lovén has considered Cotteau's paper very carefully in his wonderful work on *Pourtalesia*. This work, communicated to the Swedish Academy in 1882, was published in 1883, and I had to thank the author for a copy in 1884—and subsequently to the appearance of my paper in the GEOLOGICAL MAGAZINE.

Cotteau describes two species of *Echinoconus*=*Galerites* from the Cretaceous of Cuba.[2]

In the diagnosis of this form the apical system is pentagonal and projects; there are *five genital plates* (*basals*) *broadly perforated*, the madreporite is *prolonged into the centre of the system*, and the ocular plates are small and *intercalated* at the angles of the genital plates, and are minutely perforated. *The generative plates* (*basals*) *are separated by the oculars* (*radials*) *and the postero-lateral generative plates are separated by the large madreporite.*

The ambulacral plates have the pores directly superposed abactinally, and they are close and show, near the ambitus to the peristome, a more or less pronounced tendency to group themselves in triple pairs. Peristome small, circular, and barely incised.

Periproct elliptical, rather large, *placed in the inferior face and very close to the peristome.* The shape of the test is tall, circular and globular, the upper face rounded, the lower tumid, and flat near the peristome.

M. Cotteau says that he placed the little species in the genus

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[1] New Series, Decade III. Vol. I. No. 1, p. 10, January, 1884.

[2] *Galerites Lanieri* (D'Orbigny), Cotteau, *op. cit.* p. xi. fig. 7—13.

Echinoconus because of its globular form. He states that it "se distingue nettement de toutes ses congénères," and he admits that the having five generative plates perforated is a "charactère qui n'avait pas encore été signalé chez les *Echinoconus*."

I have placed those details which do not agree with the genus *Galerites*=*Echinoconus* in italics, and it will be noticed that in nearly all, the structural characters are not those of the typical forms.

The well-developed and perforated fifth basal plate, the separation of the basals by the radials, and the separation of the posterior plates by the madreporite, are unknown in any other species of the genus. The position of the periproct, situated as it is in the inferior surface of the test and close to the peristome, would not convey the idea of *Galerites* to any one who has studied the well-known forms of the European Cretaceous rocks.

The figure given by Cotteau of the structure of the ambulacra does not correspond with that of *Galerites*; for, notwithstanding the obliquity of the imperfect triplets, the plates are all low and small primaries, and do not therefore correspond with the interesting character of the ambulacral plates given so truthfully by Lovén in the instance of *Galerites*=*Echinoconus albogalerus*.

II. The second species, called *Echinoconus Antillensis*, Cotteau, and described *op. cit.* p. 13, figs. 1 and 2, pl. 2, has not the apical system preserved, and moreover has an eccentric apex and an oblique peristome!!

Now the question arises, can the first species come within the genus *Galerites* = *Echinoconus*? The reply might take the form of a question, why should the species not be placed in *Holectypus*?

The details of the apical system would interfere, but the form is nearer *Holectypus* than *Galerites*. With all respect to the opinion of M. Cotteau, I must decline to admit such elasticity in a well-diagnosed genus, and considering that he finds a variety of the first species without any triple pairing, I am bound to believe that the forms are not *Echinoconus*.

Lovén accepted without reserve the dictum that the forms described by Cotteau were indubitable *Galerites* = *Echinoconus*. He uses this belief in one of his interesting arguments concerning the changes which occur in the apical system and position of the periproct in time. In the work on *Pourtalesia*, p. 68, Lovén writes, "In *Echinoconus* and *Anorthopygus* the vent is posterior, subventral, and the costal (genital-basal) No. 5 is present and without a pore."

On page 71 Lovén writes after considering the Spatangoids: "It has been seen that when in the Echinoconidæ the periproct has retreated far back from the calyx (apical system), the costal 5 (that is, the fifth generative plate or basal), which had been suppressed, was reinstated again, and that the normal condition returned even so far as to allow the efferent duct of the corresponding sexual gland to perforate it."

That species vary during time, and that the changes may become so important as to necessitate the introduction of the forms into new genera, can hardly be doubted; but if the proof is to be scientific, it must be capable of verification from positive facts.

Hence in order to agree with Lovén in the instance of *Galerites*, we must have proof that the earliest known species of it had the structures which "were suppressed," Now in "Les Etudes" there are descriptions and delineations of the apical system of the common *Galerites* which, like all Lovén's positive work, are marvels of exactitude. But there is no trace of the fifth plate, nor was the corresponding gland evidenced. In fact, there is no evidence whatever that any suppression took place, and it is quite possible that *Galerites* was the descendant of forms without the fifth plate.

Lovén would have it believed that in long periods of time the fifth basal and gland appeared, the madreporite extended backwards, the ocular plates (radials) grew inwards, and separated the basals. and the position of the anus altered as well as the character of the ambulacra. A new form came from an old one by modification during time. Unfortunately the age of the Cuban forms is not so very long after that of the deposits containing *Galerites*. Perhaps there was no difference in the times of deposit. For the Cuban deposits are Cretaceous, and not Miocene or later.

There was no time for the changes. Again, it must be felt, notwithstanding the assertions of the very distinguished naturalists, that there is little or nothing to link the Cuban forms with the group they are presumed to descend from. It must end in confusion worse confounded than the present state of the genera of the Echinoidea, if species are to be associated which have different structures of grave physiological importance. Under the conditions of our present knowledge, it really appears, that although the Cuban forms may have descended from a *Galerites*, they do not come within the generic diagnosis of the previously known species, and that they are so exceptional as to require entry into another genus.

III.—PRELIMINARY NOTE ON SOME TRAVERSES OF THE CRYSTALLINE DISTRICT OF THE CENTRAL ALPS.[1]

By Professor T. G. BONNEY, D.Sc., LL.D., F.R.S., Pres. G.S.

DURING the past four years I have made several traverses of the Central Alps from north to south, and venture to lay before you the general results as bearing in some respect on the geology of the Highlands.

1. The ordinary rules of stratigraphy as learnt from most lowland districts are commonly quite inapplicable to the Alps. The most highly crystalline and the older beds often form the higher parts of a mountain region, the newer the lower. The newer beds frequently appear to underlie and dip regularly beneath the older. Gigantic folds, overturns, and overthrust faults abound. The true stratigraphy of a district can only be worked by the exercise of patient and cautious inductions from observations extended over a wide area.

2. The non-crystalline rocks of the Alps are of various ages. There are some of Carboniferous age, but the great period of con-

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[1] Read before the Geological Section (Section C) of the British Association at Aberdeen, September, 1885.

tinuous deposition generally begins with some part of the Trias. The conglomerates, which often occur at the base of the non-crystalline deposits, indicate that the principal metamorphism of the crystalline series was anterior to both these epochs. There is at present no reason to suppose that either in the Central Alps or for some distance on each side there are any representatives of the earlier Palæozoics. I believe that the conglomerates at the base of the Carboniferous contain fragments of the later crystalline rocks of the Alps as well as of some of the earlier—though I do not assert that these crystalline rocks have undergone no modifications since Carboniferous times.

3. In the heart of the principal Alpine chains, and apparently at the base of everything, are coarsely crystalline gneisses. These differ little from granites, except that they generally—almost always—exhibit a certain foliation, and occasionally seem to be interbedded with thin seams of micaceous schists or flaggy fine-grained beds.

4. On examining these latter, we find reason to believe that they are generally due to crushing. Their strike agrees with that of the apparent foliation in these older rocks, and with that of a foliation which is also present in the newer crystalline rocks. This corresponds with the strike of the main physical features of the district, and with the cleavage in the included troughs of sedimentary rock. It runs for great distances with remarkable uniformity, *e.g.* from the Maderanerthal to the upper part of the Lukmanier Pass the strike of this foliation does not materially vary from W.S.W.—E.N.E.

5. This apparent foliation is due to the development of extremely thin films of a micaceous mineral. In many cases it causes the rock to bear the aspect of a highly micaceous schist; yet on examining a transverse section, it is seen distinctly to be a crushed gneiss; *i.e.* though so conspicuous, it is a mere varnish. As it thus differs materially from a true foliation, it would be convenient to give it a name, and I should propose to call it the "sheen surface." It is, in fact, a kind of "cleavage foliation," that is, a foliation due to cleavage, and subsequent to it. But though from certain points of view so conspicuous, its minerals often constitute a very small part of the mass of the rock.

6. The pressure which has produced this "sheen surface" has in many cases affected the orientation of the minerals, which are present in the true "foliation" layers of the more distinctly foliated, *i.e.* mineral-banded, rocks. It has affected these minerals as pressure affects the constituents of a sedimentary rock.

7. In the crystalline schists very commonly the "sheen surface" corresponds with the original foliation surface, as in the slates the cleavage sometimes does with the bedding. This is due to the fact that the axes of the great folds often make a very high angle with the horizon. It may, however (like a cleavage surface), be seen crossing the foliation at all angles.

8. Thus a non-foliated crystalline rock may be rendered to some extent foliated by pressure (followed by a certain amount of mineralization); *i.e.* some gneisses may be formed by crushing from granites,

some schists out of other igneous rocks. It may obliterate an earlier foliation, or it may intensify it, or it may produce an independent and more fissile foliation.

In this sense gneiss may be said to pass into granite, because a rock which is now, both macroscopically and microscopically, a gneiss, may prove to be a granite which has in some parts yielded to pressure more than in others.

9. As we pass outwards from the great central granitoid masses, we come to gneisses and schists, where the evidence of some kind of stratification becomes more marked; bands of crystalline limestone, quartzite, and granulite being associated with mica schist of many kinds—simple, garnetiferous, staurolitic, actinolitic, and the like—the bands of different mineral character and composition varying from mere streaks to layers up to many yards in thickness. In fact, the above-named rocks are associated exactly as limestones, sandstones, and clays are associated in the ordinary sedimentaries.

10. Although the crushing of a crystalline rock *in situ*, or the squeezing and shearing of a breccia or conglomerate of crystalline fragments, occasionally gives rise to local difficulties, these are on a small scale, and sedimentary beds belonging to the Palæozoic or later periods of deposition are generally readily distinguishable from the whole of the crystalline series. Though folded and faulted in the most extraordinary manner, the members of the two series can generally be separated, and in the Alps there is no evidence of a mingling of the one with the other in the process of rolling out or squeezing together; so that after patient study and microscopic examination we can generally decide without hesitation whether a particular set of rocks has originated from the crystalline or the sedimentary series. I do not say that we can always decide whether a schist or a gneiss has originated from an igneous rock or from an older schist or gneiss, but I think that in the Alps we can say that it has originated from one of these. Fortunately, intrusive rocks are rare in the Palæozoic and later deposits in this part of the Alps.

11. Thus, although the Tertiary metamorphism of the Alpine rocks is very important, it is more pretentious than real, and its effects seem to have been the greatest where it has found a rock already crystalline to act upon. Hence I believe that every true gneiss and schist in the Alps is much older than the Carboniferous, and is probably older than any member of the Palæozoic period.

IV.—On the Literature and Nomenclature of British Fossil Crocodilia.

By Arthur Smith Woodward,
of the British Museum (Natural History).

(With a Folding Table of Genera and Species).

Of all groups of fossil reptiles, there is perhaps none in greater need of critical revision than that comprising the Crocodilia. The remains of this order already discovered are so numerous, and the various descriptive accounts of them so scattered and disconnected,

LIST OF BRITISH FOSSIL CROCODILIA HITHERTO RECORDED OR DESCRIBED WITH REFERENCES.

BY ARTHUR SMITH WOODWARD.

NAME AND AUTHOR.	DATE.	FORMATION.	LOCALITY.	REFERENCE TO ORIGINAL DESCRIPTION.	NATURE OF TYPE.	WHERE PRESERVED.	REMARKS.
SUB-ORDER PARASUCHIA. Family STAGONOLEPIDÆ. STAGONOLEPIS, Agassiz. —— *Robertsoni*, Agass.	1844	Upper Trias	Elgin	Agassiz, "Rech. Poiss. Foss. V.G.R." p. 139, pl. 31, f. 13, 14.	(Ventral) scutes	Elgin Museum	First shown by Huxley to be Crocodilian, Quart. Journ. Geol. Soc. vol. xv. (1859), pp. 440-460, pl. xiv. Further elucidated by the same author, *Ibid.* vol. xxxi. (1875), pp. 423-438, pl. xix.; and "The Crocodilian Remains found in the Elgin Sandstones, &c." Mem. Geol. Surv. Mon. iii. (1877).
SUB-ORDER MESOSUCHIA. Family TELEOSAURIDÆ. MYSTRIOSAURUS, Kaup.							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
—— sp., Phillips.	...	Oxfordian	Long Marston	... ...	... ...	... ...	See *Metriorhynchus* sp.
—— *Manselii*, Hulke.	...	... ...	... ...	... ...	... ...	... ...	See *Dakosaurus Manselii*.
—— *rostro-minor*, Geoffr. (Owen).	1841	Kimmeridgian	Shotover	Owen, "Brit. Assoc. Rept. 1841, p. 82.	... ...	... ...	Subsequently described by Phillips as *Steneosaurus palpebrosus*; see *Metriorhynchus palpebrosus*.
—— *Oxonensis*, De la Beche.	...	... ...	... ...	... ...	... ...	... ...	See *Steneosaurus Boutilieri*.
[illegible]	...	... ...	... ...	... ...	... ...	... ...	[illegible]

——— *minor*, Owen.	...	... ...	... ...	... ...	...		(*suchus.*
OWENIASUCHUS, A. S. Woodw. ——— *major*, Owen, sp.	1879	Purbeckian.	Durdlestone Bay, Swanage	*Brachydectes major*, Owen, "Foss. Rept. Weald and Purb. Form." Suppl. ix. (Mon. Pal. Soc. 1879), p. 3, pl. i. fig. 2.	Mandibular ramus	British Museum	
——— *minor*, Owen, sp.	1879	Purbeckian.	Durdlestone Bay, Swanage	*Brachydectes minor*, Owen, *ibid*, p. 5, pl. i. fig. 3.	Mandibular ramus	British Museum	
Family BERNISSARTIDÆ ? THERIOSUCHUS, Owen. ——— *pusillus*, Owen.	1879	Purbeckian.	Durdlestone Bay, Swanage	Owen, "Foss. Rept. Weald, and Purb. Form." Suppl. ix. (Mon. Pal. Soc. 1879), p. 10, pl. iii. figs. 3-16, and pl. iv.	Skeleton and skull	British Museum	*See also* Owen, Quart. Journ. Geol. Soc. vol. xxxv. p. 149, pl. ix.
"*Crocodilus ? Saulii*," Owen.	1851	"Greensand."	Sussex	Owen, "Foss. Rept. Cret. Form." (Mon. Pal. Soc. 1851), p. 45, pl. xv.	Scutes and associated skeletal fragments	British Museum	Name given in Owen's "Brit. Foss. Rept.," Index to vol. ii. p. vi. Correct genus indeterminable.
SUB-ORDER EUSUCHIA. Families CROCODILIDÆ and ALLIGATORIDÆ. CROCODILUS, Laur. ——— *Cantabrigiensis*, Seel.	1869	Cambridge Greensand.	Cambridge	Seeley's "Index, etc.," p. xvii. (name only).	Vertebra	Woodwardian Museum Cambridge	Described in Quart. Journ. Geol. Soc., vol. xxx. (1874), p. 693.
——— *icenicus*, Seeley.	1876	Cambridge Greensand.	Cambridge	Seeley, Quart. Journ. Geol. Soc. vol. xxxii. pp. 437-439.	Vertebra	Woodwardian Museum, Cambridge	
——— *Spenceri*, Buckland.	1836	London Clay.	Sheppey	Buckland, "Geol. and Min." (Bridgw. Treat.), vol. i. p. 251; vol. ii. pl. 25', f. 1.	Hinder portion of skull	British Museum	=probably *C. champsoides*, Owen.
——— *champsoides*, Owen.	1850	London Clay.	Sheppey	Owen, "Foss. Rept. Lond. Clay," pt. ii. (Mon. Pal. Soc. 1850), p. 31, pl. iii.	Skull	British Museum	
——— *Toliapicus*, Owen.	1850	London Clay.	Sheppey	Owen, *ibid*, p. 29, pl. ii. fig. 1; pl. iiA.	Skull	British Museum	
——— *Hastingsiæ*, Owen.	1847	Upper Eocene.	Hordwell	Owen, "Brit. Assoc. Rep." Trans. Sect. p. 65.	Skull, etc.	British Museum	Further elucidated (with plates) by Owen in Mon. Pal. Soc. 1850; *see also* Huxley, Quart. Journ. Geol. Soc. vol. xv. (1859), pp. 678-680, pl. xxv.
ALLIGATOR, Cuvier. •——— *Hantoniensis*, Searles Wood.	1846	Upper Eocene.	Hordwell	Searles Wood, Charlesworth's Lond. Geol. Journ., 1846, p. 6, pls. i. vi. vii.	Portion of skull	British Museum	Referred to "*C. Hastingsiæ ?*" by Owen, Mon. Pal. Soc. 1850. Well-known figure in Nicholson's "Palæontology," vol. ii. p. 210, fig. 560.
Family GAVIALIDÆ. GAVIALIS, Linnæus. ——— *Dixoni*, Owen.	1850	Middle Eocene.	Bracklesham	Owen, "Foss. Rept. Lond. Clay," pt. ii. (Mon. Pal. Soc. 1850), p. 46, pl. x.	Portions of mandible with teeth	British Museum	*See also* Dixon's "Geol. and Foss. Sussex," 1st edit. pp. 208-211 (2nd edit. pp. 253, 254).

—so commonly has it been the custom to take advantage of each successive "find" for the manufacture of a new generic or specific name, however fragmentary the materials, and so frequently have species been imperfectly compared and characterized,—that a most intricate and perplexing synonymy has arisen, which it would require long-continued research by the profoundest of specialists to unravel. Moreover, cases are not unknown, in which type specimens have subsequently proved to be unfortunate restorations, and the occasional disregard of priority in nomenclature has also contributed to increase the confusion.

In this country, indeed, there appears to have been no attempt, as yet, to collect the desultory materials and determine exactly the extent of our present knowledge of British forms: and it is the remembrance of this circumstance that has induced the writer to bring together the following connected account, in the hope that it may tend to point out the chief deficiencies and facilitate further research. It is proposed to give complete references to all studies on the subject hitherto published in England, and also enumerate the more important allusions to British species to be found in the memoirs of Continental authors.

TRIASSIC CROCODILIA.

The earliest members of the order at present definitely known, either in the Old World or the New, are discovered in the Upper Trias, and belong to at least three genera. Only one has been recorded from British strata,—*Stagonolepis*, from the yellow sandstones near Elgin, N.B.,—and this does not appear to be represented by more than a single species. It was originally described by Agassiz,[1] in 1844, on the evidence of a fragment of scaly armour, and considered by him—though he had only examined drawings of the fossil—to constitute a genus of ganoid fishes; twelve years later, however, through the assiduous researches of the Rev. Dr. Gordon, of Birnie, a more perfect series of remains enabled Prof. Huxley[2] to demonstrate the reptilian and crocodilian nature of the animal, and the subsequent discovery of other materials has rendered it possible to produce an elaborate monograph on the subject.[3] Prof. Huxley makes known fragments of the skull and mandible, teeth, vertebræ, ribs, interclavicle, scapula, coracoid, humerus, ilium, ischium, pubis, femur, tibia?, fibula (or radius), metatarsals, and scutes, and the anatomy of this form is considerably elucidated by comparing the various parts with the beautifully preserved remains of its close ally, *Belodon*, from the Upper Keuper beds, near Stuttgart.[4] Nothing seems to have been added to our knowledge of *Stagonolepis* since

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[1] L. Agassiz, "Rech. Poiss. Foss. Vieux Grès Rouge," p. 139, pl. 31, figs. 13, 14.

[2] T. H. Huxley, "On the *Stagonolepis Robertsoni* (Agassiz) of the Elgin Sandstones," Quart. Journ. Geol. Soc. vol. xv. (1859), pp. 440-460, pl. xiv.

[3] T. H. Huxley, "The Crocodilian Remains found in the Elgin Sandstones, etc.," Mem. Geol. Survey, Mon. iii. (1877): see also the Professor's paper "On *Stagonolepis Robertsoni*, and on the Evolution of the Crocodilia," Quart. Journ. Geol. Soc. vol. xxxi. (1875), pp. 423-438.

[4] See memoirs on this genus by H. von Meyer in the "Palæontographica," vols. vii. x. and xiv. (1861-1865).

1877, and it has not been recorded from any but one Scotch locality. *Belodon* had a much wider range, having been found in Würtemburg.[1] India,[2] and North America;[3] and *Parasuchus*[4] is a more generalized crocodilian from India.

JURASSIC CROCODILIA.

The Lower Lias has not hitherto yielded any fossils of this order; but in the higher beds of Whitby, and their Continental equivalents, abundant remains of Teleosaurs are continually discovered, and numerous remarkably perfect skeletons and skulls are to be found in various museums. The earliest specimen made known to science was figured and described by Chapman and Wooller in the "Philosophical Transactions" so long ago as 1758,[5] and the authors of these quaint communications perceived the general resemblance of their fossil in outward shape to that of the living Gavials and Alligators, thus suggesting an affinity: but none received a name until the publication of the Bridgewater Treatise, in which Buckland devoted a plate[6] to the illustration of three typical examples, and referred them all to an undefined species, *Teleosaurus Chapmani*, König MS. Five years later, in his second Report on British Fossil Reptiles read before the British Association,[7] Prof. (Sir Richard) Owen gave a detailed account of the specimen represented in fig. 1 of Buckland's plate just quoted, and subsequently attached the MS. name of *T. brevior* to a fine skull in the British Museum; in 1854, Mr. Charlesworth[8] brought forward evidence of possibly another form, terming it *T. ischnodon*, but publishing no definition; in 1861, Owen's "Palæontology" appeared, with the figure of a detached vertebra designated *T. brevirostris*;[9] in 1876, Prof. J. F. Blake[10] described Owen's (MS.) *T. brevior* under the name of *Steneosaurus brevior*; in 1880, Prof. H. G. Seeley[11] applied the provisional name of *T. eucephalus* to a fragmentary skull—also from Whitby—in the Woodwardian Museum, Cambridge; and quite lately, in his "History of

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[1] H. von Meyer, *loc. cit.*

[2] R. Lydekker, "The Reptilia and Amphibia of the Maleri and Denwa Groups," Palæontologia Indica, ser. iv. vol. i. pt. 5 (1885).

[3] E. D. Cope, "On the Reptilia of the Triassic Formations of the Atlantic Region of the United States," Proc. Amer. Phil. Soc. vol. xi. (1871), pp. 444–446 (reprinted in Ann. and Mag. Nat. Hist., [4] vol. vi. pp. 498-500).

[4] R. Lydekker, *loc. cit.*

[5] William Chapman, "An Account of the Fossile Bones of an Allegator, found on the Sea-shore, near Whitby, in Yorkshire," Phil. Trans., vol 50, pp. 688-9, pl. xxii. (*b*), and Wooller, "A Description of the Fossil Skeleton of an Animal found in the Alum Rock near Whitby," *ibid.*, pp. 786–790, pl. xxx. This specimen was presented to the Royal Society, and is now in the British Museum.

[6] Rev. W. Buckland, "Geology and Mineralogy, etc.," vol. ii. p. 35, pl. 25. An early figure of a skull from Whitby is also given by E. Charlesworth, in "Mag. Nat. Hist.," n.s., vol. i. (1837), p. 532, fig. 65.

[7] British Association Reports, 1841, pp. 73–81.

[8] E. Charlesworth, British Association Reports, 1854, Trans. Sections, p. 80.

[9] R. Owen, "Palæontology," 2nd edit., p. 299, fig. 103 [1].

[10] R. Tate and J. F. Blake, "The Yorkshire Lias" (1876), p. 244, pl. i. figs. 1-3.

[11] H. G. Seeley, "On the Cranial Characters of a large Teleosaur from the Whitby Lias," Quart. Journ. Geol. Soc., vol. xxxvi. (1880), pp. 627-634, pl. xxiv.

British Fossil Reptiles,"[1] Sir Richard Owen has reprinted his previous (1841) description of *T. Chapmani*, and also added particulars of *T. brevior*, without attempting to incorporate the results of recent Continental research.[2]

According to MM. Deslongchamps,[3] whose views on the subject appear to be now generally adopted, none of these forms are referable to *Teleosaurus* proper, and ought rather to be placed in the genera *Mystriosaurus* of Kaup and *Pelagosaurus* of Bronn,—the broad-faced types, with much depressed cranium and upwardly directed orbits, belonging to the former, and those with long slender snouts and more laterally placed orbits, widely separated, to the latter. The present Professor at Caen, M. Eugène Deslongchamps, regards the Whitby Museum specimen described by Owen (figured by Young and Bird,[4] and also in Buckland's fig. 1, pl. 25), as the type of *Mystriosaurus Chapmani*, König sp., and the instructive original of plate 15 (Crocodilia) in Owen's "British Fossil Reptiles,"[5] as a typical example of *Pelagosaurus Brongniarti*, Kaup sp.[6] With the latter, also, he would associate the specimens shown in figs. 2 and 3 of Buckland's plate 25;[7] and, under the same rearrangement, *Teleosaurus brevior* would be relegated to *Mystriosaurus*.

Both these genera (or sub-genera) are represented by numerous specimens in the Continental Museums, chiefly from the Upper Lias of Boll, in Würtemberg, and of Curcy, in Normandy, and the distinctive features of *Pelagosaurus* were very definitely elucidated by the elder Deslongchamps:[8] it is more difficult, however, to comprehend the precise particulars in which *Mystriosaurus* departs from the generic type of *Steneosaurus*,[9] and though Winkler, not long ago,[1] published a most elaborate study of its specific variations, he appears to have left the wider question of its affinities altogether untouched. The latter palæontologist endeavours to show that all the specimens hitherto described really belong to a single species, divisible into two varieties, one English and one German; and he accordingly proposes (*loc. cit.* p. 83) to apply the name of *M. Stukelyi*[2] to both, with the varietal adjunct of *Chapmani.* in the case of the first, and *Bollensis* in that of the second. But the ordinary rules of priority in nomenclature render it doubtful whether such a solution of the difficulty will meet with general acceptance.

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[1] *Op. cit.*, vol. iv. pp. 130–139.

[2] Unfortunately, in this extensive work, there are no particulars as to the date at which each successive part appeared; but as references on previous pages of the same volume (e.g., on p. 66) relate to papers published so recently as 1880, the following description of the Teleosaurs cannot have been *printed* before that or a later year.

[3] E. E. Deslongchamps, "Notes Paléontologiques" (1863-1869), and "Le Jura Normand: Etudes Paléontologiques des Divers Niveaux Jurassiques de la Normandie," Monographie iv. (1877-8).

[4] Young and Bird, "Geological Survey of the Yorkshire Coast," 2nd edit., 1828, pl. xvi. fig. 1.

[5] It may be noticed that this (British Museum) specimen is not described in Sir Richard Owen's letterpress, although the plate is cited at the commencement of the Section (vol. iv. p. 130). Measurements, however, are given by M. Eugène Deslongchamps, "Le Jura Normand," Mon. iv. p. 11.

[6] To this species also, M. Deslongchamps assigns Chapman and Wooller's original specimen, and the restored figure given in Owen's "Mon. Foss. Rept. London Clay," pt. ii. (Mon. Pal. Soc., 1850), pl. xi. figs. 2, 2*a*.

[7] *Vide* Deslongchamps, "Le Jura Normand," Mon. iv. pp. 8-13, *passim*.

[8] See works of Eugène Eudes Deslongchamps already cited: the descriptions of *Pelagosaurus* are largely based upon the studies of J. A. Eudes Deslongchamps "Mémoires sur les Téléosauriens de l'Epoque Jurassique du Département du Calvados, Mém. i," Mém. Soc. Linn. Normandie, vol. xiii. [*Pelagosaurus typus* is here described as *Teleosaurus temporalis*, but the mistake was afterwards rectified.]

[9] In 1877, Eugène Deslongchamps ("Le Jura Normand," Mon. iv. p. 8, *note*) announced a forthcoming paper on this subject, to be published in the Bull. Soc. Zool. France: the writer, however, has not been able to meet with it either in that journal, or in any of the Caen publications.

Teleosaurus itself, as now usually restricted, appears to be well represented in certain horizons of the English Oolites, and ranges at least from the Bathonian to the Kimmeridgian beds inclusive. Prof. Sir Richard Owen[3] has identified teeth and vertebræ of the typical species. *T. Cadomensis*, Geoffr., from the Great Oolites of Enslow (near Woodstock) and Stonesfield, and also considers[4] a cervical vertebra from the Lower Oolites of Chipping Norton to indicate a very closely allied form. The same distinguished palæontologist, in his "British Fossil Reptiles," also founds a new species, *T. latifrons*,[5] upon the greater portion of a skull from strata of Great Oolite age in Northamptonshire, but the teeth and some other important parts are wanting; and Prof. Phillips, in his "Geology of Oxford," adds two more from the well-known Oolitic Flagstones of Stonesfield, which he designates *T. brevidens* and *T. subulidens*, respectively, in allusion to the shape of the teeth. The former species[6] is founded upon a remarkably complete skull and mandible, and the latter[7] upon a nearly perfect mandible, with several other fragments; and associated with the remains of both are numerous vertebræ and limb-bones, of which the Professor figures an instructive series. The genus has not hitherto been recorded from the Oxfordian or Corallian deposits; but Sir Richard Owen[8] gives the name of *T. asthenodeirus* to a few detached vertebræ found in the Kimmeridge Clay of Shotover Hill, and Mr. J. W. Hulke[9] has made known the discovery of an undoubted *Teleosaurus* snout in the equivalent clays of Dorsetshire. This Kimmeridgian specimen is especially remarkable for the expansion of its terminal extremity, and accordingly received the name of *T. megarhinus*, Hulke.

The remaining Teleosaurs of the Jurassic period seem to belong to about six or seven generic types; the earliest are referable to the *Steneosaurus* of Geoffroy St.-Hilaire, and *Teleidosaurus* of Deslongchamps; and those of the Middle and Upper Oolites chiefly belong to *Æolodon* (H. von Meyer), *Metriorhynchus* (H. von Meyer), *Dakosaurus* (Quenstedt), and *Machimosaurus* (H. von Meyer). Mr. E. T. Newton[1] has also described a fragmentary mandible, probably crocodilian, from the Coral Rag of Weymouth, and this, if rightly determined, may possibly indicate another genus.

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[1] T. C. Winkler, "Étude sur le genre *Mystriosaurus*," Archives du Musée Teyler, vol. iv. fasc. i (1876).

[2] On the assumption that the Whitby fossil described by Stukely at the beginning of the last century [Philosophical Transactions, 1719, pp. 963–968 (No. 360), pl. i.] belongs to this genus; the original specimen, however, is now in the British Museum, and is certainly a Plesiosaur.

[3] R. Owen, British Association Reports, 1841, p. 81.

[4] *Ibid.* p. 81.

[5] Sir R. Owen, *Op. cit.*, vol. iii. p. 141, pl. xvii. (Crocodilia).

[6] Prof. John Phillips, *op. cit.* pp. 186–189. [7] *Ibid.* pp. 194, 195.

[8] R. Owen, British Association Reports, 1841, p. 81.

[9] J. W. Hulke, "Note on a Fragment of a Teleosaurian Snout from Kimmeridge Bay, Dorset," Quart. Journ. Geol. Soc. vol. xxvii. (1871), p. 442, pl. xviii. This specimen was discovered by Mr. Mansel-Pleydell, and presented by him to the British Museum.

Of *Steneosaurus*, the French Oolites appear to have furnished about twenty forms, and among British fossils, nine others have already been named and described; at least three of the latter, however, were originally placed with this genus on very questionable grounds, and there is abundant reason for suspecting that they ought rather to be referred to *Metriorhynchus*. It is also unfortunate that the three cranial modifications made known by Sir Richard Owen are not compared or contrasted with those previously described by Deslongchamps; and, with the exception of *Steneosaurus Boutilieri*, Deslong.,[2] Mr. Hulke's *S. Stephani*,[3] from the Cornbrash of Closworth, Dorset, is thus the only English species yet satisfactorily defined. Those described by Owen[4] are *S. Geoffroyi*, from the Great Oolite near Oxford; *S. laticeps*, also from this formation and locality; and *S. temporalis*, from the "Oolitic Freestone" of Bath: all are founded upon more or less complete skulls, but there are no particulars as to the collection in which the type-specimen is preserved in either case. Phillips[5] records a fragment of jaw, from the Kimmeridgian of Shotover Hill, under the rather indefinite[6] name of "*S. longirostris*, Cuv."; and a cranial fossil of Oxfordian age, in the Woodwardian Museum, Cambridge, is regarded by Seeley[7] as the type of a new species, *S. dasycephalus*.

Teleidosaurus does not appear to have been recorded as yet from British strata, nor is there much definite information regarding the occurrence of *Metriorhynchus* in this country. Deslongchamps, indeed, seems to be the only palæontologist who has hitherto attempted to determine any English fragments of the last-named genus, and he incidentally refers to the occurrence of *M. superciliosus*, de Blainv. sp., in the Oxford Clay near Oxford,[1] and of *M. hastifer*, Desl., in the Kimmeridgian.[2] He further adds an interesting statement[3] regarding the large mandible from Kimmeridge Bay, described by Sir Richard Owen[4] under the name of *Pliosaurus trochanterius*, and expresses his opinion that it certainly belongs to the present Crocodilian form.

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[1] E. T. Newton, "Notes on a Crocodilian Jaw from the Corallian Rocks of Weymouth," Quart. Journ. Geol. Soc. vol. xxxiv. (1878), pp. 398–400, pl. xvi.

[2] Under this name M. Deslongchamps ("Notes Paléont." p. 230, pl. xvi. fig. 2) mentions a plaster cast of a skull and mandible from the Cornbrash near Oxford, received from the Bristol Institution, and labelled "*Crocodilus Oxoniensis*, Conybeare"; and in describing his outline figures of the specimen, he further refers to it as "*Steneosaurus Oxoniensis*, De la Beche." But Mr. Edward Wilson, to whose kindness the writer is indebted for particulars of the Crocodilian fossils now in the Bristol Museum, is unable to discover any such label in the collection; and the present whereabouts of the original specimen seems to be unknown. The specific name is evidently MS. only.

[3] J. C. Mansel-Pleydell, "Note on a Gavial Skull from the Cornbrash of Closworth," Proc. Dorset Nat. Hist. and Antiquarian Field Club, vol. i. (1877), pp. 28-32, pl. i. A detailed descriptive paragraph is supplied by J. W. Hulke.

[4] Sir Richard Owen, "History of British Fossil Reptiles, vol. iii. pp. 144, 145, pl. 18, 19 (Crocodilia).

[5] J. Phillips, "Geology of Oxford," p. 388 (with woodcut of tooth).

[6] See Deslongchamps, "Notes Paléontologiques," pp. 110, 111.

[7] H. G. Seeley, "Index to Reptilia, etc., Woodwardian Museum," 1869, p. 140.

To *Metriorhynchus*, also, we may safely refer several fossils from the neighbourhood of Oxford, described by Professor Phillips as Steneosaurian.

Among its many important characters,[5] this genus is especially remarkable for the great development of the pre-frontal bones which overhang its laterally-placed orbits; the elongated, oval form of the upwardly directed external nostril; the large relative size of the three or four anterior teeth in each jaw; and the general contour of the hinder cranial region. Fragments of the snout may also be easily distinguished by the palatal surface exhibiting two parallel longitudinal grooves. Moreover, it seems even possible to recognize detached vertebræ by the peculiarities of the neural arch, for the pedicle on each side is slightly prolonged downwards, thus presenting the appearance of clinging to the centrum.[6]

Now, nearly all these characters are well shown in Prof. Phillips' figures of "*Steneosaurus palpebrosus*" and "*Steneosaurus gracilis*,"[7] and these species are also confined to the Upper Oolites, like the majority of the Metriorhynchs of the Continent.[8] Of the first named form, a large series of remains, from the Kimmeridge Clay of Shotover, are preserved in the Museum at Oxford, and the Professor illustrates both skull and mandible, vertebræ, shoulder girdle, and ischium, besides several limb bones more doubtfully referred to the same animal. *M. gracilis* was founded upon less perfect materials: the type-specimen is a fragmentary skull, discovered by Mr. Wood Mason, and especially interesting on account of its being of Portlandian age. In the same work (p. 319), Prof. Phillips further describes a number of vertebræ from the Oxford Clay of Long Marston, said to agree very closely with those of the Shotover species; and it may be added that an anterior portion of a mandible, obtained by Mr. Cunnington from the corresponding beds of Chippenham, and now in the British Museum (No. 46323), undoubtedly belongs to the same generic type.

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[1] E. E. Deslongchamps, "Notes Paléontologiques," p. 319. [2] *Op. cit.* p. 353.

[3] While describing the mandible of *Metriorhynchus Moreli*, M. Deslongchamps writes as follows (*op. cit.* p. 329):—"Cette forme de mâchoire inférieure, toute différente de celle des autres animaux de la même famille, rapelle assez la même pièce appartenant à un animal d'une tout autre famille, c'est-à-dire des Sauroptérygiens; je veux dire celle qui est décrite par S. Rich. Owen, comme étant celle d'un *Pliosaurus* qui, d'ailleurs, s'écarte notablement de la forme habituelle du *Pliosaurus grandis*, et qu'il nomme *Pliosaurus trochanterius*.[4] Il est hors de doute que la mâchoire décrite ici appartient au genre Métriorhynche; il serait en effet trop étrange que cette forme fût venue précisément se rencontrer dans toutes les assises où se trouvent des Métriorhynches, et que je puisse rapporter des pièces en tout semblables par leurs caractères particuliers de taille, de force et de brièvété ou d'allongement du museau, à chacune de mes espèces de Métriorhynches, aussi bien dans les couches calloviennes qu'oxfordiennes et kimméridgiennes; et, en effet, je connais dès maintenant des mâchoires inférieures se rapportant parfaitement aux *Met. superciliosus*, *Moreli*, et *hastifer*."

[4] R. Owen, "Monograph of the Fossil Reptilia of the Kimmeridge Clay" (Mon. Pal. Soc., 1868), p. 7, pl. iii. figs. 3–5.

[5] E. E. Deslongchamps, *op. cit.* p. 132.

[6] Character mentioned by H. E. Sauvage in Bull. Soc. Géol. France, [3] vii. (1879), p. 695. See also figures and descriptions of vertebræ by E. E. Deslongchamps in Lennier's "Etudes géologiques et paléontologiques sur l'Embouchure de la Seine, etc.," 1870, pp. 50–52, pl. x.

[7] J. Phillips, "Geology of Oxford," pp. 380–388, with woodcuts. The Kimmeridge specimens were previously noticed by Owen (Brit. Assoc. Reports, 1841, p. 82) under the name of *Steneosaurus rostro-minor*, Geoffr.

[8] Referring to the Continental forms, Deslongchamps remarks (*op. cit.* p. 134):—"On les retrouve dans les diverses assises oxfordiennes, et leur maximum de développement semble avoir lieu dans les assises kimméridgiennes supérieures et portlandiennes."

The presence of *Machimosaurus* among British fossils has only once been doubtfully suggested. M. Sauvage[1] thinks it likely that the tooth recorded by Phillips[2] from the Kimmeridge Clay of Hardwick, under the name of *Goniopholis sp.*, will eventually prove to belong to this genus; and our present information regarding the range of each form renders the suggestion very plausible.

Another generic type of Kimmeridgian age is the *Dakosaurus* of Quenstedt.[3] Detached teeth closely resembling those described on the Continent are not unfrequently met with in several Kimmeridge Clay localities, but with the exception of certain derived fossils in the Potton deposits, no British specimens appear to have been definitely identified until 1869, when Mr. Wood Mason[4] presented a note on the subject to the Geological Society, and Prof. H. G. Seeley[5] recorded other specimens from the well-known pits near Ely. Somewhat later in the same year, Mr. Hulke[6] made known a crocodilian jaw from the typical deposits of Kimmeridge Bay, which exhibited a number of teeth of an undoubtedly similar character, and was associated with vertebræ and other skeletal fragments; in 1870, the subsequent fortunate recognition of the skull of the same individual provided materials for a much more satisfactory study, with the result that the distinguished palæontologist just mentioned relegated the form to a new species of *Steneosaurus*—*S. Manselii*, Hulke—and thus deposed the generic name, *Dakosaurus*, to the rank of a synonym.[1] These instructive specimens (with many other Kimmeridge fossils) had been presented by their discoverer, Mr. Mansel-Pleydell, to the British Museum, where they have since occupied a prominent position in the Crocodilian series, and a little more than a year ago formed the subject of another memoir—on this occasion by Sir Richard Owen.[2] While confirming completely the descriptive details published by his fellow-worker fifteen years ago, Sir Richard now endeavours to maintain that the fossils in question are really generically separable from *Steneosaurus*, and thus proposes to establish a new genus, *Plesiosuchus*—so named in allusion to the fact, that the shape of the skull and the disposition of the nasal bones indicate a nearer approach to the later broad-faced Crocodiles than any of the earlier Teleosauria. On the other hand, Mr. Hulke[3] still ventures "to deprecate any disturbance in the original name"; and it is remarkable that in the paper just quoted,[4] Sir Richard Owen makes no allusion to the asserted identity of the teeth with those of Quenstedt's *Dakosaurus* (1858), when he suggests the removal of this species from the true Steneosaurs.

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[1] H. E. Sauvage, "Mémoire sur les Dinosauriens et les Crocodiliens des Terrains Jurassiques de Boulogne-sur-Mer," Mém. Soc. Géol. France, [2] vol. x. mém. ii. (1874), p. 50. It should be noted that the statement in this Memoir, to the effect that *Machimosaurus* and *Goniopholis* are synonymous, was withdrawn in 1879, on the discovery of more complete remains of the former genus.

[2] J. Phillips, *op. cit.* p. 332.

[3] A. Quenstedt, "Der Jura," 1858, p. 785, pl. 97, figs. 8–11.

[4] J. Wood Mason, "On *Dakosaurus* from the Kimmeridge Clay of Shotover Hill," Quart. Journ. Geol. Soc. vol. xxv. (1869), pp. 218–220 (with woodcuts).

[5] H. G. Seeley, "Index to Reptilia, etc., Woodwardian Museum," p. 109.

[6] J. W. Hulke, "Notes on some Fossil Remains of a Gavial-like Saurian from Kimmeridge Bay, collected by J. C. Mansel, Esq., establishing its identity with Cuvier's *Deuxième Gavial d'Honfleur, Tête à museau plus court* (*Steneosaurus rostrominor* of Geoffroy St.-Hilaire) and with Quenstedt's *Dakosaurus*," Quart. Journ. Geol. Soc., vol. xxv. (1869), pp. 390–400, pls. xvii. xviii.

The interesting remains of *Dakosaurus* in the Woodwardian Museum, Cambridge, recorded and briefly noticed by Prof. Seeley,[5] have not hitherto been fully described. Among others, they include a remarkably complete skull from the Kimmeridge Clay of Ely (which has received the name of *D. lissocephalus*, Seeley) and several other portions of the skeleton. There is also a worn tooth of *Dakosaurus*—probably indicative of a new species (Seeley)—from the Coral Rag of North Grimston.[6]

As might be expected from the stout character of its teeth, it may be noted that *Machimosaurus* has proved to be a comparatively short-snouted Mesosuchian. Being of the same (Kimmeridgian) age, MM. Sauvage and Liènard's valuable memoir[7] on this generic type is especially interesting when considered in connection with *Dakosaurus*.

PURBECK AND WEALDEN CROCODILIA.

The majority of the crocodilians of this age at present known are characterized by broad-faced skulls; and only two genera, probably related to the older Teleosaurs, appear to have been hitherto described in Britain. *Hylæochampsa vectiana*, Owen,[1] is founded upon the hinder portion of a small (young?) skull—discovered by the Rev. W. Fox, M.A., in the Wealden beds of the Isle of Wight—and its precise affinities are somewhat uncertain. *Petrosuchus levidens*, Owen,[2] is a Purbeck species, determined upon the evidence of a fragmentary skull and mandible from Swanage, and also rather problematical in its affinities: it is regarded, however, as intermediate between the long- and short-snouted types.

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[1] J. W. Hulke, "Note on a Crocodilian Skull from Kimmeridge Bay, Dorset," *ibid.* vol. xxvi. (1870), pp. 167-172, pl. ix. This identification was subsequently questioned by H. E. Sauvage ("Sur le genre *Dacosaurus*, Quenstedt," Bull. Soc. Géol. France [3], vol. i. 1873, pp. 380–385), who endeavoured to prove the Mosasaurian character of the detached teeth met with in Continental deposits. Subsequent research, however, has failed to strengthen such an opinion.

[2] Sir Richard Owen. "On the Cranial and Vertebral Characters of the Crocodilian Genus *Plesiosuchus*, Owen," Quart. Journ. Geol. Soc. vol. xl. (1884), pp. 153-159. See also Owen's "Brit. Foss. Reptiles," vol. iii. pp. 146-151, (Crocodilia) pl. 20, figs. 1-4.

[3] Presidential Address. 1884, Proc. Geol. Soc. pp. 45-47.

[4] Quart. Journ. Geol. Soc. 1884.

[5] H. G. Seeley, "Index to remains of Reptilia, etc, Woodwardian Museum," 1869, pp. 109, 92.

[6] Can this be the same as certain Corallian teeth in the British Museum, bearing the MS. name of *Pliosaurus teretidens*, Owen?

[7] H. E. Sauvage and F. Liènard, "Mémoire sur le genre *Machimosaurus*," Mém. Soc. Géol. France, [3] vol. i. mém. iv. (1879). Abstract by H. E. Sauvage in Bull. Soc. Géol. France, [3] vol. vii. (1879), pp. 693-697.

The first of the broad-faced forms that received a name was that constituting Owen's genus *Goniopholis*,[3] and, though little was known of it at first, the original species has subsequently proved to have so many congeners, that it is now found convenient to group them all together in a family termed GONIOPHOLIDÆ;[4] Mr. Hulke, indeed, ventured, a few years ago,[5] to regard their peculiarities as justifying the erection of a new suborder, METAMESOSUCHIA, but the advisability of such a procedure has lately been called in question.[6]

Goniopholis—so named, in 1841,[7] in allusion to the rectangular form of the (dorsal) scutes—was founded upon a number of detached teeth discovered by Dr. Mantell in the Wealden of Tilgate Forest, and upon a large portion of a skeleton from the Purbeck Beds of Swanage, which also exhibited one or two dental fragments of a similar type. Subsequent discoveries in the Wealden of Sussex, and the Purbecks of Dorset, have contributed further to elucidate the genus, adding two new species, and the recent fortunate acquisition of almost complete skeletons from the celebrated Wealden strata of Bernissart in Belgium, seems destined to supply nearly all deficiencies in our knowledge of its osteology. The skull was not made known until 1878, when Hulke[8] (followed, in the case of one specimen, by Owen[9]) was able to describe all its more salient features: and it is only about two years since Dollo[10] gave an outline of the general skeletal characters as revealed by the Belgian examples.

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[1] R. Owen, "Monograph of the Fossil Reptilia of the Wealden and Purbeck Formations," Suppl. vi. (Mon. Pal. Soc. 1873).

[2] R. Owen, "Mon. Foss. Rept. Weald. and Purb. Form." Suppl. viii. (Mon. Pal. Soc., 1878), p. 10, pl. vi.

[3] R. Owen, "Report on British Fossil Reptiles, Part II." Brit. Assoc. Rep. 1841, p. 69.

[4] L. Dollo, "Première Note sur les Crocodiliens de Bernissart," Bull. Mus. Roy. Nat. Hist. Belgique, vol. ii. (1883), p. 334.

[5] J. W. Hulke, "Note on two Skulls from the Wealden and Purbeck Formations, indicating a new Sub-group of Crocodilia," Quart. Journ. Geol. Soc. vol. xxxiv. (1878), p. 381.

[6] L. Dollo, *loc. cit.* p. 329.

[7] R. Owen, Brit. Assoc. Reports, 1841, p. 69.

[8] J. W. Hulke, paper already cited, Quart. Journ. Geol. Soc. vol. xxxiv. pp. 377–381, pl. xv. It should be added, that Prof. Huxley previously described a portion of an indeterminable crocodilian skull from the Wealden of Brook, Isle of Wight, in his paper of 1875, Quart. Journ. Geol. Soc. vol. xxxi. p. 432, pl. xix. fig. 3: these later discoveries indicate its probable reference to *Goniopholis*.

[9] R. Owen, "Monograph of the Fossil Reptilia of the Wealden and Purbeck Formations," Suppl. viii. (Mon. Pal. Soc., 1878), p. 7, pl. v.

[10] L. Dollo, note already quoted above.

The teeth of the "Swanage Crocodile,"[1] and Mantell's specimens from Tilgate Forest, being remarkable for their thick and stunted shape, the original type-species was named *G. crassidens*.[2] A second form, described by Hulke and Owen in 1878,[3] is known as *G. simus*, Owen, and it is to this that the magnificent skeletons from Bernissart may be referred: the teeth are more slender than in the first-named species and the head apparently less tapering. *G. tenuidens* is the name given by Owen,[4] in 1879, to a fragmentary mandible from the Middle Purbecks of Durdlestone Bay, and indicates a small form, characterized by the slenderness of its teeth; and four vertebræ, from the Wealden of Cuckfield, are figured in Owen's "British Fossil Reptiles"[5]—though not described—under the name of *G. carinatus*.

The Middle Purbecks of Durdlestone Bay have also yielded an interesting series of remains of "Dwarf Crocodiles," some of which are undoubtedly referable to the same family. They were described by Sir Richard Owen[6] in 1879, and distributed among three new genera, termed respectively *Nannosuchus*, *Brachydectes*, and *Theriosuchus*, and considered to indicate about four species.

Nannosuchus gracilidens is founded upon the skull and mandible; but associated vertebræ, scutes, and portions of limb-bones are also known. The second genus—with its two species, *B. major* and *B. minor*—is indicated by mandibular rami, particularly remarkable on account of the very small proportion of the jaw bearing teeth. *Brachydectes* ("short-biter"), however, is a name preoccupied by Cope, in 1868,[7] for a Carboniferous Labyrinthodont, and it will, therefore, be necessary to substitute a new term. It may not be inappropriate to suggest the generic title of *Oweniasuchus*, employing the name of one to whom we owe the earliest definite information regarding British Fossil Crocodiles, and so many contributions to the subject that have subsequently appeared.

The remains of *Theriosuchus pusillus* include not only the skull and mandible, but also a nearly complete skeleton, and its osteology is thus comparatively well known. M. L. Dollo has suggested[8] that it may possibly belong to his newly determined family of Bernissartidæ; and if this view prove correct, the fact of its dorsal scutes being apparently on the *Goniopholis* plan—in two rows, with peg-and-socket articulation—instead of following the plan of *Bernissartia*, will become of especial interest.

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[1] G. A Mantell, "Wonders of Geology," 3rd edit. (1839), vol. i. pp. 387–389, pl. i.

[2] R. Owen, Brit. Assoc. Reports, 1841, p. 69. Further details are given in Owen's "Mon. Foss. Rept. Weald. and Purb. Form.," Suppl. viii (Mon. Pal. Soc., 1878), pp. 1–6, pls. i -iv.; and Mr. Willett's Wealden skull, described by Mr. Hulke, *loc. cit.*, is regarded as probably belonging to this species.

[3] Memoirs in Quart. Journ. Geol. Soc. and Mon. Pal. Soc. already quoted.

[4] R. Owen, "Mon. Foss. Rept. Weald. and Purb. Form.," Suppl. ix. (Mon. Pal. Soc., 1879), p. 2. pl. i. fig. 1.

[5] *Op. cit.* pl. 14 (Crocodilia).

[6] R. Owen, "Mon. Foss. Rept. Weald. and Purb. Form.," Suppl. ix. (Mon. Pal. Soc., 1879). See also Quart. Journ. Geol. Soc. vol. xxxv. pp. 149–152, pl. ix.

[7] E. D. Cope, "Synopsis of the Extinct Batrachia of North America," Proc. Acad. Nat. Sci. Philadelphia, 1868, p. 214.

[8] L. Dollo, *loc. cit.* p. 335.

The genus *Suchosaurus*, Owen,[1] is very imperfectly known. It is founded upon detached teeth from the Wealden of Tilgate Forest, characterized by their laterally compressed and slightly curved shape, and ornamented with prominent longitudinal ridges; they are especially remarkable from the fact, that the compression is from side to side, and the opposite trenchant "carinæ" hence anterior and posterior, while the corresponding edges in most other crocodilian teeth that are known to possess them are distinctly lateral in position. Only one species, *S. cultridens*, is as yet recognized, and with the teeth Sir Richard Owen has ventured to associate a peculiar type of Wealden vertebra that can scarcely be referred to any other Saurian hitherto met with in those deposits.

Only one other British crocodilian fossil of Wealden (?) age appears to have been hitherto described. It is a small slab of "Greensand," from the neighbourhood of Hastings, exhibiting a few scarcely determinable scutes and other skeletal fragments, and described by Sir Richard Owen,[2] in 1851, under the name of "*Crocodilus? Saulii.*" Later discoveries, of course, suggest its affinities with such forms as *Bernissartia* or the Purbeck genera.

CRETACEOUS CROCODILIA.

No members of the Crocodilian order seem to have been recorded from any of the British Cretaceous formations, except the Cambridge Greensand. While the corresponding beds in North America afford evidence both of the decline of the Mesosuchia and the rise of the Eusuchia, at this period—and while satisfactory remains of the last-named suborder are also known from Continental deposits—the only discoveries hitherto recorded in Britain are a few procœlian vertebræ from Cambridge. These are regarded by Prof. Seeley as indicative of two species, probably belonging to the genus *Crocodilus*, and accordingly named *C. cantabrigiensis*[3] and *C. icenicus.*[4]

EOCENE CROCODILIA.

Of all known Crocodilia of the Eocene period, perhaps no series can claim to be of greater interest than that discovered in the London and Hampshire Basins. Not only—as Sir Richard Owen has pointed out—are the characters both of Crocodiles, Alligators, and Gavials, observed in the various forms from this single area, while the three families are nowhere found associated at the present day; but many of the fossil remains already known are also of a remarkably satisfactory character, and include fine cranial specimens in an excellent state of preservation.

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[1] R. Owen, Brit. Assoc. Reports, 1841, p. 67; and "Mon. Foss. Rept. Weald. etc.," Suppl. viii., (Mon. Pal. Soc. 1878), p. 12, pl. iv. figs. 5–8.

[2] R. Owen, "Monograph of the Fossil Reptilia of the Cretaceous Formations," (Mon. Pal. Soc., 1851), p. 45, pl. xv.

[3] H. G. Seeley, "Index to Reptilia, etc., in Woodwardian Museum" (1869), p. xvi, and "On Cervical and Dorsal Vertebræ of *Crocodilus cantabrigiensis* (Seeley) from the Cambridge Upper Greensand," Quart. Journ. Geol. Soc. vol. xxx. (1874), pp. 693–695.

[4] H. G. Seeley, "On *Crocodilus icenicus* (Seeley), a second and larger Species of Crocodile from the Cambridge Upper Greensand, contained in the Woodwardian Museum of the University of Cambridge," *loc. cit.* vol. xxxii. (1876), pp. 437–439.

The first notice of a Crocodile from the London Clay of Sheppey was by Baron Cuvier,[1] who based his determination upon a detached cervical vertebra; an imperfect skull was subsequently discovered by Mr. Spencer, in 1831, and figured by Buckland[2] under the name of *C. Spenceri*; and in 1850, the Palæontographical Society published an exhaustive monograph by Prof. (Sir Richard) Owen,[3] which embraced an account of all the fossil remains of this order, from British Eocene deposits, at that time available. With the exception of a brief, but valuable contribution to our knowledge of the Hordwell species, by Prof. Huxley,[4] no further additions to the literature of the subject seem to have been made since the appearance of this classical memoir; and the subsequent discoveries of crocodilian remains in the same beds have apparently afforded no evidence of any new specific form.

Among the Sheppey fossils, two species are indicated not merely by the skulls, but also by numerous portions of the vertebral column; there is, however, no very definite information as yet concerning the rest of the skeleton, and isolated fragments of limb-bones and dermal scutes are the only remains hitherto forthcoming for study. To one of these species Sir Richard Owen gives the name of *C. Toliapicus*, regarding a fine skull and mandible in the British Museum as the type; and describes the second species as *C. champsoides*, upon the evidence of another cranial fossil, likewise preserved in the National Collection. In regard to Buckland's *C. Spenceri*, founded in 1836, the Professor displays some hesitation, and eventually declines to recognize the priority of the name by expressing doubts as to the possibility of determining the precise relationship of Spencer's less perfect fossil to the more complete specimens under description.[5]

A series of crocodilian vertebræ, obtained by Mr. Frederic Dixon, from the Lower Eocenes of Bognor, Sussex, probably belongs to *C. Toliapicus*, Owen;[6] and science is indebted to the labours of the same indefatigable investigator of Sussex fossils for the discovery of undoubted fragments of a Gavial in the Bracklesham Beds. Sir Richard Owen[7] has described the latter under the name of *Gavialis*

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[1] G. Cuvier, "Ossemens Fossiles," 2nd. edit. (1824), vol. v. pt. ii. p. 165.

[2] Rev. W. Buckland, "Geol. and Min." 2nd edit. (1837), vol. i. p. 251; vol. ii. p. 36, pl. 25′, fig. 1.

[3] R. Owen, "Monograph of the Fossil Reptilia of the London Clay," Part II. (Mon. Pal. Soc., 1850).

[4] T. H. Huxley, "On the Dermal Armour of *Crocodilus Hastingsiæ*," Quart. Journ. Geol. Soc. vol. xv. (1859), pp. 678-680, pl. xxv.

[5] On this curious method of solving the difficulty, see the remarks of Dr. Léon Vaillant, "Etude zoologique sur les Crocodiliens fossiles tertiaires de St.-Gérand le Puy," Biblioth. l'Ecole Hautes Etudes, vol. vi. pp. 10, 11. It may be added, that this memoir contains valuable information respecting European Tertiary Crocodilia described before its date of publication (1872).

[6] R. Owen, "Mon. Foss. Rept. Lond. Clay," pt. ii. p. 36. See also Dixon's "Geology of Sussex," 1st edit. p. 207, pl. xv. figs. 1, 2 (2nd edit. p. 253, pl. xv. figs. 1, 2), in which Sir Richard Owen names it "*C. Spenceri*, Buckland."

[7] R. Owen, *op. cit.* p. 46, pl. x. Also F. Dixon, *op. cit.* 1st edit. p. 208 (2nd edit. p. 253).

Dixoni, founding the species upon portions of the mandible and teeth, and provisionally associating with these a slender femur and vertebræ.

But the most completely known of British Eocene forms is the *Crocodilus Hastingsiæ*, Owen,[1] of which the more or less perfect remains occur abundantly in certain horizons in the Hordwell Cliffs, Hampshire. With the exception of the characters of the limb-bones and scutes, the osteology of this species was very fully made known in Sir Richard Owen's monograph;[2] and the dermal armour has been subsequently described by Prof. Huxley.[3] As the result of these studies, there appears to be almost decided proof that only a single crocodilian form occurs in the Hordwell Beds, and that Searles Wood's *Alligator Hantoniensis*[4] is thus merely a variety.[5] *C. Hastingsiæ*, indeed, combines the characters both of Crocodiles and Alligators to a remarkable extent; and it also possesses some features that would quite entitle it to rank as a distinct genus, were it considered desirable to recognize as such certain early procœlian types so distinguished in North America.

None of the British Eocene species appear to have received further elucidation by discoveries on the Continent, and the writer has only succeeded in meeting with one case in which a foreign form is identified with a species previously described in Britain. This is Pictet's doubtful reference of some fragmentary fossils from the Swiss Eocenes to *Crocodilus Hastingsiæ*, Owen.[6]

With the close of Eocene times, the history of the Crocodilia in British areas seems to have ended; and the latest species yet recorded in Europe appears to be that mentioned by Gervais[7] as found in the Pliocenes of Montpellier, France.

Besides the descriptive works already referred to, the English literature of the subject also comprises some valuable general studies, and in the foremost rank may be placed Prof. Huxley's now classical memoir on the Evolution of the Crocodilia, read before the Geological Society in 1875.[8] The well-known division of the order into the three sub-orders of PARASUCHIA, MESOSUCHIA, and EUSUCHIA, is here first proposed, and appears to have met with almost universal acceptance. Sir Richard Owen, also, has contributed[1] two interesting papers upon considerations suggested by his researches on the Dwarf Crocodiles of Swanage, and the reading of the first before the Geological Society, in 1878, was followed by an important and lengthy discussion. The same distinguished palæontologist, so long ago as 1858,[2] also published an outline of the osteology of the Teleosaurian skull; and more recently, Prof. H. G. Seeley[3] has succeeded in elucidating some of the main features of the brain in that extinct group.

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[1] R. Owen, "On the Fossils obtained by the Marchioness of Hastings from the Freshwater Eocene Beds of the Hordle Cliffs," Brit. Assoc. Rep. 1847, Trans. Sections, p. 65.

[2] R. Owen, *op. cit.* pp. 37–42, pls. vi.–ix.; xii. figs. 2, 5.

[3] T. H. Huxley, paper already cited, in Quart. Journ. Geol. Soc. vol. xv.

[4] Searles V. Wood, "On the Discovery of an Alligator and of several new Mammalia in the Hordwell Cliff," Charlesworth's "London Geological Journal," 1846, p. 6, pls. 1, 6, 7.

[5] It is interesting to notice that Prof. Cope has described a curious specimen of a South American Alligator, in which the lower "canine" on one side fits into a notch, while on the other the corresponding tooth is received in a pit (Trans. Amer. Phil. Soc. vol. xiv. 1869, p 83).

[6] F. J. Pictet, "Paléontologie Suisse.—Vertébrés de la Faune éocéne," p. 89, pl. vii.

[7] P. Gervais, "Zoologie et Paléontologie françaises," 2nd edit. (1859), p. 443, pl. lix. fig. 2; pl. lvii. fig. 7.

[8] Quart. Journ. Geol. Soc. vol. xxxi. pp. 423–438, pl. xix.

In conclusion, without attempting, as yet, to enter into the merits of the various *specific* types that have been described by different authors, it will perhaps be useful to arrange our present knowledge of the subject in tabular form, and the accompanying extensive scheme is accordingly appended. (See folding Table, next p. 508.) Those names that may be regarded as synonyms on the evidence of existing literature have an asterisk prefixed to them, and in the case of species founded on Continental fossils, the particulars inserted in the columns following the name, refer to the date of identification, nature of the first recognized example, etc., of the *British* representatives.

V.—ON THE FYNNON BEUNO AND CAE GWYN BONE CAVES, NORTH WALES.[4]

By H. HICKS, M.D., F.R.S., F.G.S.

IN the Proceedings of the Geol. Assoc. vol. ix. No. 1, I have given an account of the discovery of two Bone-caves in the Carboniferous rocks on the east side of the Vale of Clwyd, N. Wales, and of the researches carried on in those caverns by Mr. E. Bouverie Luxmoore, of St. Asaph, and myself in the summers of 1883 and 1884. This summer, by the aid of a grant from the Royal Society (the Government Grant), we were enabled to employ a staff of workmen, under our personal supervision, to explore these caverns more thoroughly and with very satisfactory results. Our main object was to gain a clear idea of the physical conditions of the area when the caverns were filled with the deposits, and of the manner in which the remains had been conveyed into them. These points we think we have been able to prove to satisfaction, but it may be advisable to continue the researches for the purpose of obtaining as much confirmatory evidence as possible.

In the *Cae Gwyn Cavern* all the deposits were entirely undisturbed except by burrowing animals when we first discovered it, and great care was taken throughout to notice the conditions of the materials.

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[1] R. Owen, "On the Influence of the Advent of a higher Form of Life in modifying the Structure of an older and lower Form," Quart. Journ. Geol. Soc. vol. xxxiv. (1878), pp. 421-430; also "On the Association of Dwarf Crocodiles (*Nannosuchus* and *Theriosuchus pusillus*, e.g.) with the Diminutive Mammals of the Purbeck Shales," *ibid.* vol. xxxv. (1879), pp. 148-155, pl. ix.

[2] Portion of lecture delivered on April 29th, 1858, reported in Ann. and Mag. Nat. Hist. [3] vol. i. pp. 456-463.

[3] H. G. Seeley, "On the Cranial Characters of a large Teleosaur from the Whitby Lias," Quart. Journ. Geol. Soc. vol. xxxvi. (1880), pp. 627-634, pl. xxiv.

[4] Read before the Geological Section (C) of the British Association, Aberdeen, September, 1885.

The deposits in this cavern consisted first of a reddish clayey earth, varying in depth from two to four feet. Below this was found a more compact deposit, about 18 inches in thickness, made up of thin layers of fine marly clay, and under this the material containing the bones. This material consisted of a reddish clay with sand in places, and contained many boulders similar to those found in the the Boulder-clays of the district. Large fragments of a stalagmite floor and of stalactites occurred also in it, showing that the water action which disturbed the original materials in the cave must have been of a violent nature. Under this was found a gravelly deposit, containing fragments mainly from the hills above and no bones. In this cavern the deposits, except the lowest, have now been cleared out to a distance from the entrance of over 150 feet. It is for the most part a true tunnel cavern, with well-smoothed roof and sides. The largest chamber has just been reached at a little over 150 feet from the entrance. It is over 11 feet in length and 9 feet in height. The other chambers are small, being mainly dilatations of the tunnel, which varies from 3 to 9 feet in width. Extending from a small chamber about 45 feet from the entrance there is another branch tunnel which has been explored to a distance of about 16 feet.

The bones discovered in this cavern, according to Mr. W. Davies, F.G.S., of the British Museum, to whom all the bones found in both caverns have been submitted, belong to the Lion, Hyæna, Bear, Badger, Wolf, Fox, Great Irish Deer, Reindeer, Red Deer, Roebuck, Rhinoceros and Horse. A flint scraper was also found last year in association with the remains at a distance of 45 feet from the entrance.

The *Fynnon Beuno Cavern* is partly a fissure and partly a tunnel-cavern. From the entrance inwards for a distance of about 40 feet it is a true tunnel-cavern, and there is a branch-tunnel extending from this for a further distance of over 50 feet, ultimately opening out on the hill-side above the main entrance. Another tunnel communicates with an extensive fissure cavern which had evidently been disturbed at some time by mining operations (though I could obtain no information as to when).

In the undisturbed parts of this cavern the deposits were of similar character to those in the Cae Gwyn Cave. This cavern, however, being for some extent an open cavern, had probably been inhabited in Neolithic, or perhaps later times, as a quantity of charcoal was found at two points at distances of from 20 to 24 feet from the entrance. Several well-worked flint flakes were found at different points in this cavern, in association with bones of the Mammoth, Rhinoceros, etc. Dr. Evans recognized them as of the type of the wrought flakes found in Kent's Cavern, they are white and porcellanous, and show indications of having been used, but not rolled by water action. Worked bones and others broken by man were also found. The bones were exceedingly plentiful in the cavern, and showed indications of having been gnawed freely, evidently when in a fresh condition, hence proving clearly that they had been conveyed into the cavern soon after the animals had died.

Some *album græcum* was also found in each of the caverns, therefore the evidence points conclusively to their having been dens occupied by beasts of prey. I think we are quite justified also in supposing from the positions of the flakes and worked bones, that the caverns were occupied by man, or at least that the district was inhabited by man when the Mammoth, Rhinoceros, Reindeer, Hyæna, etc., roamed about the area. The bones found in this cavern belonged to the following animals, viz. Lion, Wild Cat, Hyæna, Bear, Wolf, Fox, Wild Boar, Great Irish Deer, Reindeer, Red Deer, Roebuck, Bos, Mammoth, Rhinoceros, and Horse. The remains were much more plentiful in the Fynnon Beuno than in the Cae Gwyn Cave. Among the specimens found in the two caverns, there were over 80 jaws belonging to various animals, and more than 1300 loose teeth, including about 400 Rhinoceros, 15 Mammoth, 180 Hyæna, and 500 Horse teeth. Other bones and fragments of bones occurred also in very great abundance.

As these caverns are over 400 feet above present sea-level, and nearly 300 feet above the river Clwyd (the height given in my paper to the Geologists' Association was understated), it is clear that very great physical changes must have taken place in this area since the time that the marine sand was conveyed into these caverns. The broken stalagmite floor, sometimes 10 to 12 inches in thickness, and the broken stalactites 6 to 8 inches across, show that the water action must have been also of a violent nature. The position of the bones in some places under still adherent parts of this stalagmite, and the presence of marine sand in the hollow parts of the bones show that the bones must have been in the caverns before the sea finally receded from them. The presence also of a material, in every respect like the Boulder-clay of the district filling up the caverns, points to the probability that the so-called Upper Boulder-clays of this district were deposited, for the most part at the time, or subsequent to the infilling of these caverns. Along the hill-sides in the ravine in which the caverns are situated, sands and clays similar to those found in the caverns, and containing marine shells, are found at about the same horizon, and in the hills to the S.E. at much greater elevations.

Cae Gwyn Cave is over 60 feet, and Fynnon Beuno 42 feet above the level of the little stream, a tributary of the Clwyd, in the ravine in which they are situated. These facts suggest the following as the probable changes indicated by the deposits in the caverns. The lowest deposit in the caverns consisting almost entirely of local materials, was introduced into them by the river which then flowed in the valley at a very much higher level than at present. As time went on the valley deepened and the caverns were above the reach of the floods. They then became the abode of Hyænas and other beasts of prey, and during part of the time were probably occupied by man. Subsequently there was a period of great submergence, and when the caverns were on a level with the sea, they were filled with sandy material and the bones were embedded in it. The following are the results which have to be accounted for:—

A. The infilling of the caverns by local gravels. *B*. The occupation of the caverns by beasts of prey and by man. *C*. The formation of the stalagmite. *D*. The breaking up of the stalagmite floor, and the introduction of the Boulder-clay. The position of the caverns almost at the crest of a ridge of Carboniferous rocks makes it clear that the Boulder-clay could not have been introduced by streams; therefore the only conclusion I can arrive at is, that during a period of great submergence, either during or subsequent to the Glacial epoch, the material was introduced by marine action. Also that this submergence, and the subsequent elevation of the submerged area to its present height of over 400 feet above sea-level, must undoubtedly have taken place since the caverns were occupied by man and by the extinct animals.

VI.—ON SOME RECENT EARTHQUAKES ON THE DURHAM COAST AND THEIR PROBABLE CAUSE.[1]

By G. A. LEBOUR, M.A., F.G.S.,
Professor of Geology in the Durham College of Science, Newcastle-upon-Tyne.

SINCE the latter end of 1883 up to the present time (Sept. 1885) the inhabitants of certain portions of the town of Sunderland have been much disturbed by a series of small but distinctly sensible earth-shakes, which have caused considerable discussion in the local press and elsewhere. These shocks were chiefly felt in that quarter of the town known as the Tunstall Road, but were not absolutely limited to that locality. They were accompanied by rumblings—sometimes dull but often loud—by the rattling of crockery and furniture, and frequently by very distinct shakes of the entire framework of buildings. Often the shocks have, at night, waked up and terrified the sleeping inhabitants.

The probable origin of these disturbances has naturally been much canvassed, and blasting in quarries, shot-firing in collieries, and the passing of railway trains, have in turn been accused of causing them, and, on examination, have been found "not guilty." At the present time there is no doubt whatever that the shocks are due to some *natural* cause. As to what that natural cause may be, there is perhaps room for difference of opinion.

My friend, Mr. M. Walton Brown, of the Coal-trade Offices at Newcastle-upon Tyne, in a paper read in 1884 before the North of England Institute of Mining and Mechanical Engineers, refers to the Sunderland shocks as being genuine earth-tremors; but I think that their extremely local character—setting aside many other points inconsistent with this view of their origin—is conclusive against this being so.

In another paper read at the same time as Mr. Walton Brown's before the same Institute, I brought forward a number of facts tending to connect the phenomena above referred to with certain peculiarities in the geological structure of the district. Since that time the shocks having continued more or less continuously, and evidence of all kinds with regard to them having accumulated, I wish to lay my more mature views on the subject before Section C, in the hope that members in discussing them may help to elicit the truth.

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[1] Read before the Geological Section (C) of the British Association, Aberdeen, September, 1885.

Sunderland stands upon the Permian Magnesian Limestone. There is from 300 to 400 feet of this rock beneath the town. This rock is riddled with cavities of every size and shape. The smaller ones give a vesicular aspect to the stone in many places, but the larger ones are often true caverns due to the combined action of mechanical and chemical agencies. Many of them may be accounted for by noting how frequently masses both large and small and of all shapes of soft pulverulent matter occur in the midst of the most compact and hard portions of the limestone. How easily such soft incoherent earthy rock or "Marl" as it is called locally, can be removed by the merest percolation of rain-water, needs no proof, and that caverns would result and have resulted from such removal is clear. This action is indeed chiefly mechanical, but there is also going on at the same time a very considerable destruction or removal of rock by the ordinary chemical action of rain-water on limestone. I have shown elsewhere that every thousand gallons of Sunderland water pumped up, and ultimately thrown into the sea, represents one pound of stone abstracted. In each year the Water Company robs the Magnesian Limestone in this manner of about forty cubic yards of rock, and of course much more is carried off annually by natural channels. How large some of the cavities are which form water-cisterns in this rock may be gathered from the fact that when in sinking a shaft at Whitburn Colliery in 1874, one of them was unfortunately tapped, it yielded 11,612 gallons of water per minute for a month.

The rock then immediately underlying Sunderland is a mass of calcareous stone, mostly hard and compact, but cellular in places and earthy and friable in others, often cavernous on a large scale, full of water, and through its action continually parting with its substance, and *thus enlarging the cavities within it.*

Under conditions such as these, it follows necessarily that the vaults of cavities must from time to time give way, and in collapsing, produce concussions accompanied by noise, but limited in the area over which their effects would be felt. In short it seems to me that we have in such natural stone-falls at moderate depths a sufficient explanation of the Sunderland earth-shocks.

In the paper before alluded to I pointed out that this theory explains equally well all the facts connected with the singular fissures full of breccia ("breccia-gashes") which are common in the Magnesian Limestone of Durham, and have been a standing puzzle to Lyell, Sedgwick and all the geologists who have published accounts of the magnificent sections exhibited along the coast between South Shields and Sunderland.

Quite recently very similar shocks have been felt, as I am informed, in the neighbourhood of Middlesborough, where it is probable that they are due to the withdrawal of rock-salt which has been going on there of late years only. In this case the depth at which the cavities are being formed and rock-collapses are, as I believe, taking place, is much greater than in the Sunderland case, the borings for salt being from 1000 to 1200 feet deep.

I will conclude with a quotation from my paper on the Breccia-gashes,[1] p. 174:—"The forms of these gashes, which are gullet-shaped and tapering downwards, unlike the sea-caves; the breccia with which they are filled; the matter with which the fragments are cemented; the half-broken beds which so often bridge over the upper portions of the fissures; and the unbroken beds immediately above and below them, which would be inconceivable had the fissures and their infillings been due to real earthquakes. All these things are necessary accompaniments of the rock-collapses which, it has been shown, must in time past have happened frequently, are happening still, and must happen more and more frequently in the future."

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. Fifty-fifth Meeting, Aberdeen, 1885.

List of titles of papers bearing upon Geology and Palæontology read in other Sections of the Association than in Section C (Geology).

Section A.—Mathematical and Physical Science.

Report of the Committee on Underground Temperature.

Report of the Committee on Meteoric Dust.

C. Meldrum.—A Tabular Statement of the Dates at which and the Localities where Pumice or Volcanic Dust was seen in the Indian Ocean.

Prof. Ewing.—On Measurements of Movements of the Ground.

H. R. Mills.—Physical Condition of Water in Estuaries.

Section B.—Chemical Science.

Prof. W. Irwin Macadam.—Description of a Mineral from Loch Bhruithaie, Inverness-shire.

F. Maxwell Lyte.—On the use of Sodium or other Soluble Aluminates for Softening and Purifying hard and impure Water.

Section D.—Biology.

Prof. O. C. Marsh.—On the Size of the Brain in Extinct Animals.

Prof. E. Hull.—On the Cause of the Extreme Dissimilarity between the Faunas of the Red Sea and Mediterranean, notwithstanding their recent connection.

Prof. E. Hull.—On the Origin of the Fishes of the Sea of Galilee.

Dr. Macfarlane.—On a Microscopic Fungus in Fossil Wood, from Bowling.

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[1] See Trans. N. E. Inst. Min. Eng. vol. xxxii. (1884), where full references to most of the writers who have noticed the breccias are given.

SECTION E.—GEOGRAPHY.

J. Y. Buchanan.—Oceanic Islands and Shoals.

Gen. Sir R. Lefroy.—On the Depth of the Permanently Frozen Stratum of Soil in British North America.

SECTION G.—MECHANICAL SCIENCE.

W. Smith.—The Movement of Sand in Aberdeen Bay.

SECTION H.

Thomas Wilson.—A New Man of Mentone.

W. Pengelly—Happaway Cavern, Torquay.

Dr. J. G. Garson.—The Human Remains found in Happaway Cavern, Torquay.

Dr. R. Munro.—The Archæological Importance of Ancient British Lake-Dwellings and their Relation to analogous Remains in Europe.

PAPERS READ BEFORE SECTION C (GEOLOGY).

II.—ON THE AVERAGE DENSITY OF METEORITES COMPARED WITH THAT OF THE EARTH.

By the Rev. E. HILL, M.A., St. John's College, Cambridge.

THE mean density of the earth, though not yet exactly determined, is certainly about twice the average density of the rocks which compose its superficial crust. One conjecture which very naturally follows from this fact is that the constituents of its interior may essentially differ from the constituents of that crust. Professor Judd in his treatise on Volcanoes has alluded to this, and brings forward in addition the argument that materials are occasionally brought from below to the surface which resemble the materials of meteorites; bodies which generally have a high specific gravity and sometimes consist entirely of iron.[1] The thought has occurred to me that it would be interesting to ascertain the average specific gravity of meteorites, in order to estimate what would be the density of a body formed by the aggregation of a multitude of such objects.

To conduct such an investigation properly would involve enormous labour of research, and I have contented myself by using the materials furnished by Dr. Walter Flight's most valuable "Chapters on Meteorites," published in the GEOLOGICAL MAGAZINE, during the years 1875, 1882, and 1883. From those chapters I have obtained the specific gravities of sixty-five different meteoric masses there described. The mean of these values, found by addition and division by 65, gives as result 4·84.

This method of obtaining the mean will be correct, if the various sizes were equally distributed through each of the different specific gravities. This would be rather a rash assumption, and it may seem fairer to bring into account the different masses of the specimens. From Dr. Flight's papers, with some other materials, I have found fifty-seven cases in which both weight and specific gravity are recorded. Taking the sum of the weights, the sum of the corresponding volumes, and dividing, we obtain as final result a specific gravity of 5·71.

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[1] "Volcanoes," p. 320.

3ut in this enumeration is included the great Cranbourne meteorite, ich weighs 3½ tons, and exceeds all the rest put together. A ss so great swamps the rest, and makes the calculation unsatistory, affording at best a maximum limit. Several others are very ge. Suppose we exclude all over 250 lbs. There remain fifty-ɔ cases, and the above process applied to these yields as result a ɩcific gravity of 4·58.

[have tried yet another method. I have seen somewhere a statent that in the British Museum are specimens of 260 meteorites, which 55 are metallic. Now it becomes obvious on tabulating ɩ specific gravities that the vast majority are either metallic with ɩcific gravities lying between 7 and 8, or stony with specific ɩvities between 3 and 4. Separating the 57 cases previously ɩded to into these two groups, and finding the respective average ɩcific gravity by the second method, the results are 7·61 and 3·73. ɔm 55 specific gravities of 7·61 and 205 of 3·73, we get an average 4·55. This method is open to the objections made against the ɩt, but in a slightly less degree from the larger numbers dealt th.

It is probable that metallic masses more readily attract attention ɩn stony meteorites, but on the other hand some appear to decay ry rapidly. Thus it does not seem possible to say that either ss has a better chance of obtaining admission to our calculations; a preponderating influence on the results. We may say, therefore, a general result, that an assemblage of such meteoric masses as l upon the earth, if collected from space indiscriminately and gregated into a single mass, would form a body whose specific ɩvity would probably lie between 4·5 and 5·7, so long as its dimenns were moderate.

Such a body, however, if it grew to be of planetary size, might ɔome denser from the pressure due to its own attraction. How ɩch denser we cannot say. But since water has been compressed $\frac{1}{11}$th of its bulk under a pressure of 2000 atmospheres (Ency. it., art. Elasticity), and a like pressure would be experienced at lepth of about four miles of the earth's crust, at least as much ɩy be expected in such an aggregated mass. Such a compression ɩuld raise even the lowest of the above results, viz. 4·5, to 4·9. ɩd twice the compression would raise it to 5·4. Now 5·6 is the lue usually adopted as the best estimate of the specific gravity the earth. The density of the earth is, therefore, perfectly ɩsistent with its being an aggregation of meteoric materials. hether we regard meteorites as fragments of a planet, as ɩdensations of cometary matter, or as self-existent bodies, they ɩ certainly specimens of matter scattered widely over the solar stem, and may very possibly be fair samples of its materials. ɩd small as is the catalogue even of all we know, they contain all ɩ most important constituents of the earth's crust, and even of its l.

If the earth be an aggregate of meteoric materials, so must be the ɩer planets. Now the densest of these is Mercury with a specific gravity about 6·3; Venus is about the same as the Earth; and Mars somewhat less. All these specific gravities are perfectly consistent with such an origin. The others are very much lighter, ranging down to Saturn with a specific gravity of about 0·7. But high temperature and gaseous envelopes may have much to do with these apparent low densities: a cloudy envelope which should extend to one-fourth of the radius would halve the estimate of density. The fact that seems most seriously discordant with the hypothesis is the low specific gravity of the Moon, which is estimated at only 3·5. But this at any rate is about the specific gravity of the "stony" group of meteorites. And we may compare the fact that the superficial crust of the earth, and also some meteoric constituents, have lower specific gravities still. We naturally expect the lightest constituents on the surface of a planet, and a satellite may have affinity with the crust.

The conclusion then is that on the hypothesis that the Earth has assumed its present condition either by aggregation or solidification, out of matters previously existing within the solar system, it is probable that its nucleus will be largely composed of metallic materials. But since all the meteorites known would together scarcely load a barge, this conclusion must be admitted to rest on a very slender basis.

III.—SOME RESULTS OF A DETAILED SURVEY OF THE OLD COAST-LINES NEAR TRONDHJEM, NORWAY.

By HUGH MILLER, F.G.S., H.M. Geological Survey.

DURING a short visit to Norway in October, 1884, it appeared to the author that the best way to help to a solution the vexed questions connected with the coast-terracing of Norway was to execute a careful survey of a few square miles of some suitable coast region upon a sufficiently large scale. The neighbourhood of Trondhjem is remarkably well suited to this purpose. The map employed was partly a municipal chart on the scale of $\frac{1}{10000}$, and partly an enlargement of the Ordnance Map. The limit of all the terraces and marine deposits is the famous "strand line" west of the town, a double range of old coast-cliff cut in the rock of the mountain-side. Its upper line is 580 feet above the sea, and answers to the "marine limit" over Norway generally. Numbers of level terrace-lines have been incised—chiefly in greenish clays, like brick-clays—all along the arable slopes east of the town between this rock-terrace and the sea. Above the Bay of Leangen, two miles east of town and river, and far beyond all erosive influence of the latter, thirty of these lines were mapped one above another in the first 300 feet of ascent, a distance of one mile and a half. Many of these are small but extremely distinct, the earthy clays being well suited to retain sharp impressions of successive sea-margins, which these unequivocally are. The present coast-line, neatly etched out by the waves in Trondhjem and Leangen bays, is the key to these tiers of older ones. It also resembles them in having made little or no impression where the coast becomes rocky, the lines of incision in both cases stopping short at once when they reach the harder material. The old coast-lines are most numerous in well-sheltered positions. Thus a single pair of large terraces in an exposed situation east from Christiansten, where they face the open water of the fjord and the prevalent north-westerly storms, is represented in the recess above Leangen Bay by ten or twelve. The same fact is brought out on rising from this recess to the higher and more exposed ground. Thus, while thirty-three or thirty-four terraces are mapped below 350 feet (approximate) elevation, only nine or ten appear between that level and the rock-terraces of the upper marine limit, the numerical average height of the terraces thus rising by more than a half. In recesses of the coast further east, but beyond the map, these upper terraces seem to be preserved in considerably greater numbers. The number actually mapped was forty-three, or with the rock-terraces, forty-five. The largest number of terraces hitherto described at any one place in Norway seems to have been eighteen.

Some of the general conclusions of the author are as follows:— 1. These terraces are all post-glacial, *i.e.* formed since the rock-glaciation of the district. This is confirmed by the condition of the high coast-cliff, which has been cut in ice-rounded rock, but is not itself glaciated. It appears, however, from the fauna of the raised shell-banks of the country (as worked out by Sars and Kjerulf), in which recent shells do not rise above 380 feet, that the seas of the upper levels were still glacial; and, though the Trondhjem fjord was free from land-ice, other deeper fjords and higher coasts may still have had glaciers coming into conflict with the sea, and producing the glaciated rock-terraces described by Sexe. All the evidence obtained discountenances Sexe's view that these rock-terraces were cut out by glaciers, as well as Carl Petersen's that they were rasped out by floating-ice coasting the shores. On the clay terraces coast-ice has left no more sign of its presence than the winter freezing of our British rivers leaves upon our river terraces. 2. If the country was upraised by a succession of elevatory jerks as supposed by most geologists from Keilhau downwards, most of these would seem to have been small—much smaller, at least, than is supposed by Kjerulf. It is improbable that even Leangen Bay was secluded enough to contain a record of all the original coast-lines. The longer pauses and greater storms may have effaced an unknown number, by a process of excision exemplified in all its stages by the map. It is hard to say, in fact, where the subdivision would end if all were preserved. The smaller terraces remind the eye of the incised lines and little planes engraved on the sandbanks bordering rivers after a flood, in which case there is no periodicity in the subsidence of the waters. 3. The preservation or excision of the terraces thus seems to depend as much upon local circumstances—exposure to storms, resistance of coast-line, etc.—as upon anything else. It is impossible at present to predicate which of them shall in any given place remain. Whether elevation by jerks, therefore, be postulated or not, all hope of correlating these terraces throughout the country must be deferred until their heights have been accurately determined by level. The measurements hitherto made, not even excepting those of Professors Kjerulf and Mohn, are probably inadequate for the purpose. This observation seems to apply also to the terraces graven in rock. In their aneroid measurements of the upper strand-line at Trondhjem these observers differ by fifty-five feet. 4. On entering the mouth of the Trondhjem Valley, the terraces come under an influence other than that of the sea-waves. The valley was worked out, in deposits partly levelled out by the sea, according to the laws of river terracing under the accelerating influences of a falling sea-level. The processes of automatic river terracing are beautifully exemplified within the district mapped, in the deep lobe-shaped curve of the river just before it enters the sea. The terraces have been added one after another to the point of the lobe of land thus surrounded, which is known as Öen.

IV.—Some Results of the Crystallographic Study of Danburite.

By Dr. Max Schuster.

In studying the characters of the faces and the structure of the Danburite crystals found in Switzerland, the author has met with vicinal faces of a peculiar kind, for which he proposes the term 'transitional faces' (Tschermak, Min. Mittheil. vi. 1884, p. 511). Attention is called to the fact that these faces are easily affected by those causes which produce an unequal development of faces otherwise symmetrically disposed, and an illustration is given of the way in which their indices are numerically related to those of the principal faces of the crystal.

Paper read in Section D (Biology).

V.—On the Origin of the Fishes of the Sea of Galilee.

By Professor Edward Hull, LL.D., F.R.S.,
Director of the Geological Survey of Ireland.

When preparing a memoir for the Palestine Exploration Society on the physical history of Arabia Petræa and Palestine, I was confronted with two biological problems: one on the origin of the fauna of the Sea of Galilee (or Lake of Tiberias); the other on the cause of the extreme dissimilarity between the faunas of the Red Sea and Mediterranean, notwithstanding the ascertained fact that the seas themselves have been physically connected within very recent times. With the former problem I propose here to deal as far as the fishes are concerned; with the latter I shall deal presently.

The abundance of the fishes which inhabit the waters of the Sea of Galilee is known both from sacred and secular history, and has been testified to by several recent observers. The characters and habits of these fishes have also been ably discussed and illustrated, especially by Canon Tristram[1] and Professor L. Lartet,[2] from which it has been determined that nearly one-half of the species are peculiar to the lake and its tributaries; while of the rest only one—namely, *Blennius lupulus*—belongs to the ordinary Mediterranean fauna; two others—namely, *Chromis Niloticus* and *Clarias macracanthus*—are found in the Nile; seven other species occur in the rivers of South-western Asia; and ten more are found in other parts of Syria. Tristram considers that this assemblage points to a close affinity of the fauna of the Jordanic basin with that of the rivers of Tropical Africa (Æthiopian); but what most strikes the observer is perhaps the speciality of the species to Jordanic waters, sixteen out of a total of thirty-six species being peculiar. This view seems to be borne out also by an analysis of the molluscous forms, which are for the most part also peculiar, for no less than sixteen species of *Unio* are special to Jordanic waters.[1] Assuming that the forms which are common to Jordanic and other waters have been distributed in a manner similar to that by which we have to account for the distribution of lacustrine forms in other parts of the world, we have yet to account for the presence of the forms which are special and peculiar.

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[1] Fauna and Flora of Palestine, preface, p. xii. Mem. Palestine Survey, 1884.

[2] Poissons et Reptiles du Lac de Tibériade, Archives du Musée d'Histoire *Naturelle* de Lyon, tome iii. 1883.

This leads to a consideration of the manner in which the Jordanic basin was first formed and afterwards modified; and without entering here into this wide question, which I have endeavoured to deal with in the memoir above referred to, I may be allowed to summarize my conclusions somewhat as follows:—

In the first place, it must be recollected that as the whole region on both sides of the Jordanic valley was originally overspread by strata of the Eocene period (known as the *Nummulitic Limestone*), this region formed the floor of the ocean down to the close of the Eocene period; the only possible lands in the district may have been those of the Crystalline rocks of the Sinaitic group of mountains.

The geological period, which succeeded, that of the Miocene, was that in which land first appeared in the Palestine area. The bed of the sea was locally elevated into dry land, but at the same time most of the leading physical features by which that land is now diversified were traced out and finally determined. Chief amongst these was the line of the great Jordan-Arabah depression—marked out by a line of fault or displacement of the strata, ranging from the slopes of the Lebanon on the north to the Gulf of Akabah on the south. It seems to me probable that as the land on either side of this depression was being elevated, the displacement of the strata on either side of the great fault was also proceeding, and the floor of the sea was subsiding along the line of the Jordan valley. An inland lake of considerable extent was thus formed, the waters of which were first derived from those of the ocean itself, in which were enclosed the fishes, molluscs and other forms which inhabited these waters themselves. There are good grounds for believing that once the lake was enclosed and shut off from the outer sea by a barrier of land, it was never again physically connected with the outer sea. The saddle of the Arabah valley, rising some 600 feet above the highest limit to which the waters of the old Jordanic lake ever ascended, would have proved an effectual barrier towards the south.[1] Towards the west the barrier would have been much more elevated. Hence the living forms in the waters of the inland salt lake were isolated from those of the ocean, and had either to adapt themselves to their new conditions or to die out.

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[1] Tristram, *ibid.* p. 178. The molluscs have been also recently described by M. A. Locard, Malacologie du Lac de Tibériade, 1883.

We may suppose that the first to disappear would be the corals, crinoids, and starfishes. On the other hand, fishes, molluscs, and crustaceans, having greater powers of adaptation, would in many cases survive. Meanwhile, the law of "descent with modification" would now come into operation, and we may suppose that throughout the Miocene and Pliocene periods the process of modification in form, colour, and habit gradually proceeded. The fittest forms survived, and differentiation between those of the outer and inner seas, resulting, as we have seen, in almost an entire specific change, was effected.

The above view seems in accordance with recent observations regarding the adaptability of many marine forms to new lacustrine conditions, provided the process of change is sufficiently gradual. Professor Sollas, whose memoir on "The Origin of Fresh-water Faunas"[2] is very suggestive, arrives at the conclusion that, as the conversion of comparatively shallow continental seas into fresh-water lakes has taken place on a large scale several times in the history of the earth, this has been accompanied by the transformation of some of the marine into fresh-water forms. The Jordan valley lake, originally salt, has shrunk back into two or three lakes connected by a river. The Dead Sea alone remains salt and lifeless. The waters of the Sea of Galilee are fresh, and teem with life. In reply to my enquiry whether the above views would harmonize with his own, Professor Sollas writes: "I have always regarded the curious fishes of the Sea of Galilee as evidence of a previous marine communication, but it never occurred to me to speculate as to the age of that connection. If this sea (that of Galilee) were stocked from the Eocene ocean, it would fit in very well with the history, as I believe it, of other fresh-water faunas." It is gratifying to me to have the concurrence on this point of so able an authority. I conclude, therefore, that the special forms of fishes now inhabiting the Sea of Galilee are the descendants of those which lived in the Eocene ocean.

REVIEWS.

THE GEOLOGY OF THE COUNTRY AROUND IPSWICH, HADLEIGH, AND FELIXSTOW. By WILLIAM WHITAKER, B.A., F.G.S., etc. (With Notes by W. H. DALTON, F.G.S., and F. J. BENNETT, F.G.S.) Memoirs of the Geological Survey. 8vo. pp. vii. 156. London, 1885. Price Two Shillings.

THIS Memoir contains a detailed account of the formations that are met with in the country around Ipswich, or in the tract embraced by Quarter-sheets 48 N.W. and N.E. of the Geological Survey Map.

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[1] See Mount Seir, Sinai and Western Palestine, pp. 95 and 99, etc.

[2] Scientific Trans. Royal Dublin Society, vol. iii. ser. 2.

The Chalk forms the basement rock of the district; it comes to the surface in the bottom of some of the main valleys, but is very rarely exposed in section. Although unquestionably the Upper Chalk, no fossils are recorded. The Lower London Tertiaries (Thanet, Reading, and Oldhaven Beds) crop out only to a slight extent in the same valleys. Two of the finest sections may be seen on the left bank of the Gipping, in the large chalk-pits north of Bramford. Here London-clay and newer deposits are shown, resting on the Reading Beds, Thanet Beds, and Chalk. The occurrence of Oldhaven Beds appears to be limited to the town of Ipswich. These Lower London Tertiaries are interesting from a stratigraphical point of view, but their fossil treasures are few or but little known. Mr. Whitaker expresses the hope that more attention may in future be paid to these strata.

The London Clay extends beneath the Crag and Drift over much of the southern and eastern portion of the area, though its outcrop is almost wholly confined to the valleys. It is well exposed in many brickyards, presenting its ordinary characters of blue or brown clay with septaria, underlaid by its "basement bed," which is generally very sandy and has often a layer of flint-pebbles. Among the fossils a few shells, teeth of *Lamna*, remains of turtles, and fragments of wood have been found. The most interesting section in this formation was that at Kingston or Kyson Quay, in the valley of the Deben. This section was originally noted by Mr. S. V. Wood in 1839, and he then obtained from the basement-bed of the London-clay some small teeth resembling those of a Bat; also a portion of a small marsupial, *Didelphys Colchesteri* (discovered by Mr. William Colchester), and a portion of a lower jaw, containing the last molar tooth, which Sir Richard Owen described as that of a Monkey (*Macacus Eocænus*), but which was subsequently proved to belong to *Hyracotherium*. Referring to the extent of the older Tertiary beds, Mr. Whitaker remarks that the evidence of well-sections proves that these strata occur along the whole of the eastern border of Suffolk.

To the collector, the beds of Crag have always furnished the chief attraction in Suffolk Geology. In the area under consideration the Coralline Crag occupies a very limited portion of the ground, being exposed only at Tattingstone, Sutton, and Ramsholt. The sections, however, are of considerable interest; that at Sutton shows about 22 feet of the Crag, with (at the base) phosphatic nodules, bones of cetacea, teeth of sharks, box-stones (with Diestian fossils), etc. A general account of the Coralline Crag is reserved for a Memoir on the district around Aldborough, etc.

The Red Crag occurs over a large part of the Ipswich district, generally with a narrow outcrop at the higher part of the valley-flanks, being otherwise much masked by Glacial Drift. A general account of this formation is given, of its phosphatic nodules or "coprolites," of its organic remains, and of the unfossiliferous sand out of which in many cases the shells have been dissolved. The nodule-bed is of a conglomeratic character, like that at the base of the Coralline Crag, the most peculiar of the rock-contents being the box-stones whose fossils are of the age of the Diestian Crag of Belgium. We regret that Mr. Whitaker has not given a full list of the Red Crag fossils; for although the works of Searles Wood and Prestwich contain long lists, yet it would have been convenient for the student to have in this one volume a complete account of the palæontology of the district.

An excellent account of the literature of the Red Crag, with critical remarks, occupying over eleven pages, will be of much service to those desirous of studying what has been written about the formation. Detailed accounts of the various sections of Red Crag occupy 27 pages. Of these sections, those of Tattingstone, Felixstow, Foxhall, Sutton, Ramsholt and Bawdsey are among the best known. Mr. Whitaker concludes that the Red Crag was accumulated in a short time, geologically speaking, and that it "is a small thing" compared with our Glacial Drift or River Gravels.

Under the heading of "Glacial Drift," various deposits of Sand and Gravel, Brickearth or Loam, and Boulder-clay are included; but for classificatory purposes Mr. Whitaker would make only two divisions of the Drift. The Boulder-clay is the Upper Glacial of Wood and Harmer, the Sand and Gravel their Middle Glacial, and the Brickearth, to some extent at least, their Lower Glacial; but the strong division insisted on by Mr. Wood as occurring between the Middle and Lower Glacial Beds is not recognized by Mr. Whitaker. He states that, while he cannot disprove Mr. Wood's theory, he is disposed to think that the Brickearth may occur in the form of large lenticular masses in the Sand and Gravel. In the district there is little evidence of the occurrence of beds of Boulder-clay in the sand and gravel or with the brickearth that underlie this great sheet of clay, but such layers do occur here and there. The various Drifts are described in detail, they occur over nearly the whole of the area, and are therefore most important in their relation to agriculture, and in connection with local questions of water-supply.

The term Glacial Drift is used in a chronological sense to include all beds formed during what is known as the Glacial Period. The term Post-Glacial is, however, applied to certain River or Valley Drifts which are later than the Glacial Drift of the district, but which may in some cases have been formed while Glacial conditions still endured in portions of the British area. Among these "Post-Glacial" deposits the most interesting are the beds at Stutton Ness, containing many land and freshwater mollusca; and a deposit at Ipswich which has yielded remains of *Elephas antiquus*, *E. primigenius*, *Rhinoceros tichorhinus*, etc. Among recent deposits, the Alluvium of the Orwell is noteworthy, with its peaty deposits first described by Dr. J. E. Taylor, which have yielded teeth of the Mammoth (? derived). Accounts of Shingle and Blown Sand are also given. A chapter entitled Miscellaneous is devoted to Disturbances, and Economics. Under the latter heading we find analyses of the Pseudo-coprolites and fossil bones.

Appendices giving details of Well-sections and Borings, some Supplementary Notes to other Memoirs (relating to Sudbury and

Colchester), and a list of 314 works on the Geology and Palæontology of Suffolk, together with an Index, complete the volume.

On the whole this Memoir, like most of those issued of late years by the Geological Survey, contains a large amount of dry detailed description, far from attractive to an "ordinary reader," and not at all calculated to arouse enthusiasm in the science. And yet these details may prove of great service in many ways, both practical and scientific. We are, however, informed by the Director-General in his prefatory notice to this Memoir, that the whole of the Pliocene deposits of the East of England having now been completely surveyed and published, it is intended to prepare a Stratigraphical Monograph illustrative of them. This we presume will bring out, more clearly than could otherwise be the case, the general results of the official and other work, towards the elucidation of which the Memoirs explanatory of particular maps will furnish a solid, if not very entertaining, basis.

CORRESPONDENCE.

UNDERGROUND .HEAT.

Sir,—It was with much interest that I read in the September number Mr. J. S. Gardner's article upon the above subject, and the more so as it is rather a pet subject of my own. Though I have never succeeded in throwing so much practical light upon it as Mr. Gardner has, I ventured in an article in Belgravia as long ago as June, 1881, to forecast that the day might come when we might see "*conductors of subterranean heat ramifying like the gas pipes of a city into every house, and superseding the use of fuel.*" But I never, until now, found any one willing to treat the subject otherwise than as wild and visionary. With, however, the astonishing inventions and developments of machinery which every year presents to us, it would be nothing strange if a means were found of getting at this practically exhaustless supply of heat long before the finite quantity represented by our fuel reaches the beginning of its end. At a measurable distance beneath us we have hot air and hot water. Geysers, Mr. Gardner tells us, have actually been utilized for heating purposes. To make a geyser at a given spot would be only a question of money and skill, often probably not a greater undertaking than laying down an Atlantic cable; and the one undertaking would probably bring in as good dividends as the other.

Combe Raleigh Rectory, Honiton. W. Downes.

UNDERGROUND HEAT.

Sir,—I have read Mr. Starkie Gardner's article in your Magazine for September, with much interest. I understand him to maintain that the surface of the earth is solid from cooling, and the centre solid from pressure, but that between the two there is a fluid stratum of no great proportionate thickness; he seems to think also that the continuity of the liquid stratum is in some degree interrupted by the roots of mountain chains forming ridge-shaped projections on the lower surface of the solid crust.

Perhaps it is not generally known how nearly this resembles a theory propounded by the late Mr. Hopkins of Cambridge thirty or forty years ago. He maintained that the earth is solid at the surface from cooling, and at the centre from pressure; that the solid centre is for the most part continuous with the solid crust; but that in volcanic regions there are subterranean lakes of molten matter between the two.

I speak with no authority, but I think it most probable that the earth is solid throughout, with the possible exception of small and perhaps only temporary reservoirs of lava. The fact that the lava in neighbouring craters often stands permanently at different levels, proves that they cannot be in communication with a common reservoir; and the tremulousness of the earth's surface, which the microphone reveals, seems to me to prove only that the materials composing it are elastic and slightly flexible.

BELFAST, *9th Sept.* 1885. JOSEPH JOHN MURPHY.

MR. LYDEKKER ON *ESTHONYX*.

SIR,—The article in your August number by Mr. Lydekker on the identity of *Esthonyx*, Cope, with *Platychærops*, Charlesworth, excited my interest, and requires a few words of comment. It is of the greatest importance to determine, if possible, the identity of generic and specific forms in widely separated localities during past geological ages. This has occasionally been successfully accomplished, as, for instance, the determination of *Hyrachyus*, by Gaudry, and of *Oxyæna*, by Filhol, in France. In other cases discovery of missing parts has shown that such supposed identification were premature. Thus, I have been compelled to recede from some identifications of American with European Lemuroids.

After an examination of Prof. Owen's figures and description of *Miolophus planiceps*[1] cited by Mr. Lydekker, I find that the identity of *Esthonyx* with *Miolophus* is extremely improbable, and could as well be asserted of at least one other genus. Indeed, there is nothing in the technical characters of the superior molars to prevent the identification of *Miolophus* with *Chriacus*, *Mioclaenus* or *Deltatherium*, genera which only differ from each other in the characters of the superior and inferior premolars and inferior molars. But *Esthonyx* differs still more from the normal types in its very peculiar incisors. In order that *Miolophus* should be identified with *Esthonyx* under these circumstances, some evidence as to the characters of its incisors should be obtained, which is not the case as yet. Mr. Lydekker appears to attach some importance to a space behind p.m. 3. This space in the specimen of *Esthonyx Burmeisteri* figured by me, may be due to accident, as the maxillary bone is in bad condition, and a fissure traversed the first true inferior molar. There is also a good reason for suspecting that the genera in question are not identical. This is the presence of a loop-like inner posterior

[1] *Platychærops Richardsoni*, teste Lydekker.

cingulum, quite distinct from the rest of the crown, in *Esthonyx*, which is absent in *Miolophus*, according to Owen. Though this is not alone a generic character, in my opinion it is one of those indicators which generally accompany them. In like manner, *Miolophus* presents no important distinction from *Deltatharium*, but the wide internal lobes of the crowns lead me to suspect that such exist.

As to the name *Platychœrops*, it cannot be adopted, as its publication was not accompanied by the distinct generic description which the accepted rules of nomenclature require. E. D. Cope.

THE BATRACHIA[1] OF THE PERMIAN BEDS OF BOHEMIA.

Sir,—In Dr. Fritsch's volume we have the continuation of an extensive work which I have noticed at various times in the "Naturalist" as the successive parts appeared. I desire to add, on this occasion, my renewed commendation of the care and detail with which Dr. Fritsch continues to develope the subject, and my praise for the admirable plates which accompany the text. The species treated of are those which belong to the larger forms of the Rhachitomi, together with some of the intermediate types, such as the Dendrerpetonidæ. Of the greatest interest are two new genera of the order Embolomeri, *Chelydosaurus* and *Sphenosaurus*, where the additional vertebral centrum, entire in the type of the order (*Cricotus*), is divided into three segments, two lateral and an inferior. This is a curious discovery, especially as *Sphenosaurus* has hitherto been regarded as a reptile.[2] It also has an important bearing on the value of the order Embolomeri, which Dr. Fritsch is disposed (p. 4) to question. He thinks that the embolomerous vertebral structure is confined to the caudal region in the genus *Cricotus*, although I have figured it in the lumbar and cervical region of that genus, and described it as found in the dorsal[3] region. Dr. Fritsch reached this conclusion because he finds that in *Archegosaurus* the caudal region is embolomerous, and the dorsal region rhachitomous. His discovery of the persistence of the embolomerous condition in the dorsal region of *Chelydosaurus* and *Sphenosaurus* might have suggested to him the correctness of my observations on *Cricotus*. I add here that in *Eryops*, in which the dorsal vertebræ are rhachitomous, the caudal vertebræ are not embolomerous. So *Archegosaurus* stands alone in this respect. This determination of the characters of *Archegosaurus* by Dr. Fritsch is very useful to American palæontologists, as it has hitherto been very imperfectly described. I have stated that there are vertebræ of this type from Lebach in the Museum of Princeton College, New Jersey. As they agree exactly with Dr. Fritsch's figures of *Archegosaurus*, it is difficult to perceive why he denies the accuracy of my statement in the matter (p. 15). E. D. Cope.

[Re-published at the writer's request from the *American Naturalist*, June, 1885.]

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[1] Fauna der Gaskohle in d. Kalksteinen d. Permformation Böhmens. Von Dr. Anton Fritsch, b. ii. heft i.; Praag, 1885.

[2] These two genera should form a second family of the Embolomeri, characterized as above, which I call the Sphenosauridæ.

[3] Proc. Amer. Philo. Soc. 1884, p. 29.

OBITUARY.

THOMAS DAVIDSON, LL.D., F.R.S., F.G.S., F.L.S., &c.

BORN MAY 17, 1817; DIED OCTOBER 14, 1885.

It is with profound regret that we have to record the death of another eminent British palæontologist, whose loss from our ranks we must all deplore. Although Dr. Davidson's ancestral home was at Muirhouse, near Edinburgh, he had long resided in Brighton, and had identified himself as Chairman of the Committee with the Free Public Museum and Library of that town; to which he had also been a liberal donor.

We published in April, 1871, in the pages of this MAGAZINE, an account of Dr. Davidson's life, with a portrait of himself and a list of his Memoirs to that date. He has since completed his magnificent work on the BRITISH FOSSIL BRACHIOPODA for the Palæontographical Society (of which he was a Vice-President), which occupies five large quarto volumes illustrated with over 200 plates drawn by the author's own hands. He has prepared the article *Brachiopoda* for the "Encyclopædia Britannica"; monographed the entire series of Brachiopoda collected during the exploring expedition of H.M.S. "Challenger"; prepared an exhaustive memoir on Recent Brachiopoda now in course of publication by the Linnæan Society, besides various lesser papers in the pages of this MAGAZINE and elsewhere. He may be truly described as one of the most hard-working and single-minded Naturalists of the present century. Although living much in retirement, he had been elected an Honorary Member of all the chief Scientific Societies in Europe and America; he had also been decorated with the Gold Medal of the Royal Society in 1870, the Wollaston Gold Medal of the Geological Society in 1865, and the "Silurian Medal" by Murchison in 1868. He died at his residence, 9, Salisbury Road, Brighton, having been for some time a great sufferer from an acute affection of the lungs.[1]

As a final act of generosity, Dr. Davidson has bequeathed his magnificent collection of Recent and Fossil Brachiopoda, containing a large proportion of the "types" figured in his various works, together with his Books and Original Drawings, to the Nation, to be preserved in their entirety in the Department of Geology in the British Museum of Natural History, Cromwell Road, London, S.W.

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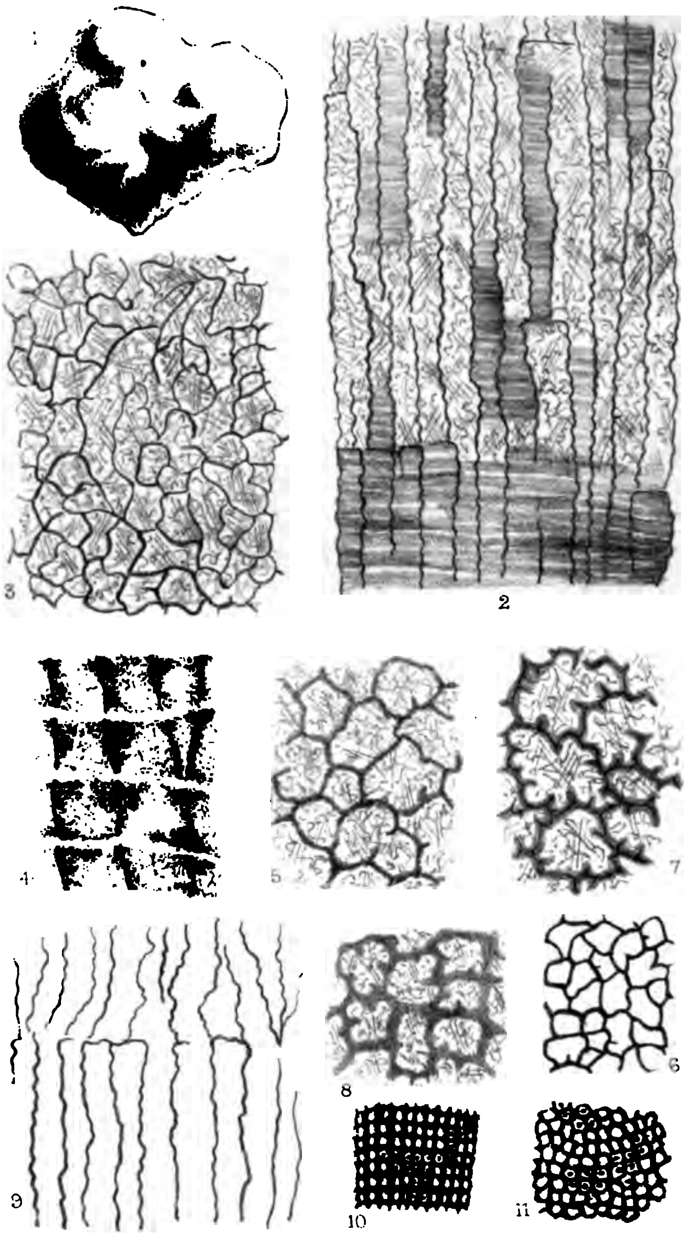
[1] His American friend, Prof. W. H. Dall, paid the last compliment to his labours in the GEOLOGICAL MAGAZINE for September (p. 429).



H.A. Nicholson del.
E.C. Woodward lith.
West Newman & Co. imp.

Solenopora compacta Billings sp.
&c. &c.

THE
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NEW SERIES. DECADE III. VOL. II.

No. XII.—DECEMBER, 1885.

ORIGINAL ARTICLES.

I.—ON THE SYNONYMY, STRUCTURE, AND GEOLOGICAL DISTRIBUTION OF *SOLENOPORA COMPACTA*, Billings, sp.

By H. ALLEYNE NICHOLSON, M.D., D.Sc., and ROBERT ETHERIDGE, jun.

(PLATE XIII.)

IN his "Palæozoic Fossils" (1861–65), Mr. Billings described, without figures, a fossil from the Black River Limestone, to which he gave the name of *Stromatopora compacta*. The description given was as follows:—"This species forms small subglobular masses, from one to two inches in diameter. The concentric lamellæ are thin and closely packed together, there being in some specimens from six to twelve layers in the space of two lines" (*op. cit.* p. 55).

In 1877, the present writers described, under the name of *Tetradium Peachii*, a singular fossil which occurred in pebbles of Ordovician Limestone contained in the Old Red conglomerates of Habbie's Howe, Pentland Hills, near Edinburgh, the source of these pebbles being at that time unknown (Ann. and Mag. Nat. Hist. ser. 4, vol. xx. p. 166).

In the same year (1877) Dr. Dybowski described a fossil from the Ordovician strata of Esthonia under the name of *Solenopora spongioides*, n.sp., his description and figures leaving no doubt of the identity of this with *Tetradium Peachii*, Nich. and Eth. jun. ("Die Chaetetiden der ostbaltischen Silur. Formation," p. 124, taf. ii. figs. 11*a*, *b*). The genus *Solenopora* was regarded as referable to the Monticuliporoids, and Dr. Dybowski defined it as follows:—

"Corallum spheroidal; corallites irregularly prismatical, of very small diameter; cœnenchyma wanting; tabulæ absent."

In 1880, we gave a further and much fuller description of *Tetradium Peachii*, from specimens which had been collected by Mrs. Robert Gray from the Craighead Limestone (Ordovician) near Girvan, Ayrshire (Monograph of the Silurian Fossils of the Girvan District in Ayrshire, p. 31, pl. i. fig. 3, and pl. ii. figs. 1, 1*b*). In this description we still adhered to the reference of the fossil to *Tetradium*, from the close resemblance of cross-sections of the tubes in many specimens to similar sections of *Tetradium*.

Sir J. W. Dawson, in a paper on the microscopic structure of the *Stromatoporidæ* (Quart. Journ. Geol. Soc. vol. xxxv. p. 53, 1879), expressed the opinion that the fossil described by Billings under the name of *Stromatopora compacta* is not referable to the Stromatoporoids. He states that it "consists of very minute hexagonal tubes, with extremely thin walls and well-developed tabulæ, which, from their strong development and continuity, give in some specimens an appearance of concentric lamination." Sir William Dawson regards the fossil as referable to *Stenopora* (*i.e.* to the Monticuliporoids).

Lastly, Mr. A. H. Foord has described (Contrib. Micro. Pal. Sil. Rocks, Canada, Geol. Survey, 1883, p. 24) a variety of this peculiar fossil under the name of *Tetradium Peachii*, var. *Canadense*, Foord, which differs from the British form in having thicker and more wavy tube-walls. Mr. Foord did not observe any tabulæ in his specimens, and suggested that the species. should be removed from the genus *Tetradium*.

So far as we are aware, the above are all the published notices of this singular fossil, the forms described as *Tetradium Peachii* by us, as *T. Peachii*, var. *Canadense*, by Foord, and as *Solenopora spongioides* by Dybowski being specifically identical with the previously-named *Stromatopora compacta* of Billings. We have long known that *Solenopora spongioides*, Dyb., was the same as our *Tetradium Peachii*, but we are indebted to our friend Mr. Foord for having pointed out to us that the *Stromatopora compacta* of Billings—which we had not seen—was really the same organism. As it is quite certain that this fossil—whatever its true nature may be—cannot be referred to either *Tetradium*, Dana, or *Stromatopora*, Goldf., we shall retain for it the generic name of *Solenopora* proposed for it by Dr. Dybowski. The species, will, therefore, stand as *Solenopora compacta*, Bill. sp. Mr. Foord's varietal name of "*Canadense*" can hardly be retained, as the Canadian specimens are the *type* of Billings's species. On the other hand, Mr. Foord was quite correct in pointing out that the Scotch specimens differ in some respects from the Canadian type, and we may, therefore, retain for these the varietal name of "*Peachii*." The Russian examples, again, appear to agree in all essential respects with the Canadian specimens. To this rectification of nomenclature we may append the following brief remarks on the structure, affinities, and geological distribution of this very remarkable organism.

Solenopora compacta, Bill. sp., in all its varieties, presents itself in the form of smaller or larger subspherical masses, from the size of a hempseed up to the dimensions of an orange, the external surface being usually lobulate. Even under a good lens, no actual structure can usually be detected as present in the surface itself, but it is common to find indications of a more or less obvious composition out of concentrically-disposed strata. Fractured surfaces have a characteristic porcellanous, sometimes obscurely fibrous aspect, and are usually white or light brown in colour. Thin sections show that the fossil is composed of very minute capillary tubes, which are in close apposition, diverge slightly from a central line, and are commonly interrupted in their growth in such a way as to give rise to a concentric lamination of the skeleton. The tubes are from a fifteenth to a twelfth of a millimètre in diameter, and are not "prismatic" or "hexagonal," but, as shown by tangential sections (Pl. XIII. Fig. 3), of very irregular shape. The walls of the tubes are singularly sinuated, or folded into minute undulations (Pl. XIII. Fig. 2), reminding us of what is seen in long sections of *Monotrypa undulata*, Nich., and other allied forms. One of the most striking features shown by thin sections is the rapid increase of the tubes by fission. This shows itself in tangential sections by the common occurrence of projecting septa-like processes, which extend into the interior of the tubes (Pl. XIII. Figs. 3, 5–8). It was the appearance of these septiform processes which originally induced us to refer the fossil to *Tetradium*; and the number of them which may be present varies greatly. Sometimes they can hardly be recognized as existing at all. At other times (Pl. XIII. Fig. 3) they occur in scattered tubes, here and there among the ordinary tubes, as is so commonly seen in the genus *Chætetes*, Fischer. Again, in many of the specimens from Ayrshire and Esthonia, these structures are extraordinarily numerous (Pl. XIII. Figs. 7, 8), giving to cross-sections of the tubes precisely the appearance, on a small scale, presented by corresponding sections of the tubes of *Laceripora*, Eichw. The fissiparous development of the tubes of *Solenopora compacta* is quite as easy to recognize in longitudinal sections (Pl. XIII. Fig. 2), as it is in tangential slices.

Cross-partitions in the tubes, or "tabulæ," are unquestionably present; but they are very variable in number. We have seen no examples in which they are so abundant, or so regularly placed, as they are said by Sir William Dawson to be in some of his specimens. In sections of some of our examples especially if they are reduced to great tenuity, they are not to be recognized as occurring at all. In most specimens there are a few of these structures present, irregularly developed, and commonly situated at the point where a tube divides into two (Pl. XIII. Fig. 2), or where a concentric line of growth is produced (Pl. XIII. Fig. 9). The walls of the tubes, as examined in long sections, are certainly imperforate. Certain specimens, however, show a peculiar granular structure of the walls, which in some respects is very similar to what is observed in the skeleton-fibre of certain Stromatoporoids. In a great many examples, further, the tubes as seen in long sections (Pl. XIII. Figs. 2 and 4) exhibit a peculiar appearance, as if the walls were formed of dark, ill-defined granules arranged in transverse lines, these lines corresponding in contiguous tubes, and being separated by corresponding clear lines, and thus giving rise to a fine concentric striation. The appearance here alluded to is not at all unlike that presented by thin sections of the massive Nullipores, when the component cells may not be very distinctly shown: but we shall speak more particularly of this point immediately.

The above being the general structure of the skeleton in *Solenopora*, it does not seem unnatural that it should have been referred to the Actinozoa. There is not, in fact, anything whatever in the main features of the fossil which would obviously distinguish it from a species of the genus *Chætetes*, Fischer, or *Tetradium*, Dana. Tangential sections of certain specimens of *Solenopora compacta*, Bill., present—the size of the component tubes apart—the closest possible resemblance to corresponding sections of *Chætetes*, while others exhibit a strong likeness to *Tetradium*. The extraordinarily minute size of the tubes of *Solenopora* would, however, certainly render it improbable that we had to deal with a species of *Chætetes* or *Tetradium*. Indeed, upon this ground alone, it might be considered as seriously doubtful if *Solenopora* could be referred to the Actinozoa at all. If it be Cœlenterate, it would perhaps more properly find a place among the Hydrozoa rather than the Actinozoa. We are not, however, acquainted with any Hydrozoön, living or extinct, with which *Solenopora* could be compared. It shows no features in its minute structure which remind us of the Hydrocorallines, and it assuredly presents no structural resemblance to any known type of the Stromatoporoidea.

The only other direction in which one might look for the true place of *Solenopora* is among the calcareous Algæ. In its external appearance, in its general texture, and in the aspect of fractured surfaces, it presents a remarkable similarity to the massive forms of the Nullipores (*Lithothamnion*). In all the Nullipores, however, as in the Algæ generally, the minute structure of the organism is essentially *cellular* and not *tubular*. In none do we find the long capillary tubes, with their transverse tabulæ and fissiparous mode of growth, such as are characteristic of *Solenopora*. Moreover, if an argument against the reference of *Solenopora* to the Cœlenterata be founded upon the fact that its tubes are much more minute than those of any known Actinozoön or Hydrozoön, the same argument may be reasonably employed, in an opposite direction, as against a reference of *Solenopora* to the calcareous Algæ. In other words, the minute structure of *Solenopora* is as much grosser than that of the Nullipores, as it is finer than that of the Cœlenterates generally. This will be seen by a reference to Pl. XIII. Figs. 10 and 11, which represent sections of a living Nullipore on the same scale of enlargement as the Figures 4 and 5 of *Solenopora*. This difference may be roughly put in this way, that while a two-inch objective is sufficient for a general examination under the microscope of a thin section of any species of *Chætetes* or *Tetradium*, one requires a one-inch objective in order to clearly make out the structure of a similar section of *Solenopora*, and one cannot recognize the characteristic structure of a section of a Nullipore with a lower power than a quarter-inch objective.

In deciding, however, as to any possible relationship between *Solenopora* and the calcareous Algæ, it is necessary to consider more minutely certain points in the structure of this curious fossil. Most examples of *Solenopora compacta* show concentric lines of growth, which differ in no essential particular from those of many "Tabulate Corals" (*e.g.* species of *Monotrypa, Stenopora, Chætetes*, etc.). That is to say, their growth was interrupted by periodic pauses, signalized commonly (though not necessarily) by a simultaneous development of tabulæ, the same tubes subsequently continuing their upward growth (Pl. XIII. Fig. 4).

In all specimens, however, of *Solenopora*, which are well preserved, we can recognize in addition a number of clear concentric lines of a different kind. These lines can be examined in longitudinal sections, and they differ from ordinary lines of growth in several points. In the first place, concentric lines of growth are mere stoppages of the tubes at a given level over the whole fossil, and they are marked either by an interruption of the tubes at this level, or, commonly, by a concentric line of tabulæ. On the other hand, the concentric lines in *Solenopora* to which we allude are concentric clear lines of calcite, which are extraordinarily close-set, and are placed at uniform distances. In this last respect, they are quite unlike ordinary concentric lines of growth, these being of such a form that they are placed at their widest distances apart in the middle of the skeleton (where the skeleton is thickest), and approximate to one another towards the margins of the same. Moreover, in very well-preserved specimens it can be shown in properly prepared longitudinal sections that these concentric clear bands in *Solenopora* are the result of an apparent interruption or deficiency of all the tubes at a series of concentric and corresponding horizons (Pl. XIII. Fig. 4). This appearance is particularly well shown in some sections of *Solenopora compacta* from the Trenton Limestone of Ontario, which our friend Dr. George J. Hinde was good enough to place at our disposal. It follows from this that the clear concentric bands of *Solenopora* are not of the nature of concentrically disposed tabulæ; but that they are rather similarly disposed deficiencies in the walls of the tubes.

It would be a very natural hypothesis that we had to deal here with a structure resembling that of a recent Nullipore, but in an imperfectly preserved condition. We might, namely, suppose that we had in *Solenopora* really to deal with a structure composed of oblong cells arranged in regular, concentrically and vertically disposed rows, such as we see in both living and extinct Nullipores (Pl. XIII. Fig. 10). All that we should have to suppose is that the cell-nuclei had disappeared in the process of mineralization, and that the cell-walls had only been preserved *in parts;* those walls which have a vertical direction being well preserved, and therefore showing as dark lines; while the cell-walls having a horizontal or concentric arrangement are badly preserved, and only appear as clear spaces. Some countenance is given to this view, as a possible one at any rate, by the not uncommon occurrence of specimens of *Heliolites* and other similar corals so preserved that the tabulæ remain as distinct dark lines, while the walls of the corallites and interstitial tubes are so badly preserved as to be almost or quite invisible. There are, however, two serious difficulties in the way of accepting any such explanation of the observed structure of *Solenopora compacta.*

In the first place, even those specimens which most clearly exhibit these close-set concentric clear lines which we have described, at the same time show in parts of long sections no traces of such clear lines, or of dark lines appearing instead of such. In *all* specimens, the tubes in places appear to have continuous walls, without any concentrically developed interruptions. In the second place, *tangential sections* of all specimens alike not only show no traces whatever of any concentric clear bands, or of any interruptions in the walls of the tubes; but, so far we can judge, exhibit appearances absolutely incompatible with anything except *the cross-sections of tubes.*

Upon the whole, therefore, while admitting our inability to adequately explain the peculiar appearances above described as seen in long sections of many examples of *Solenopora*, we do not think that these appearances afford sufficient evidence for concluding that the true structure of the fossil is *cellular.* If evidence can be obtained proving decisively the existence of a cellular structure in *Solenopora*, then the reference of the genus to the calcareous Algæ would follow as a matter of course. In the absence of such evidence, we can only leave the question of the affinities of the genus quite open.

The only remaining point upon which we may say a few words is the geological range of *Solenopora compacta*; the species being remarkable not only for its wide distribution, but also for the constancy with which it presents itself at a particular horizon. In North America it occurs, apparently in great abundance, in certain parts of the Trenton and Black River Limestones. In Scotland, it is found in the Ordovician limestones of Craighead, near Girvan, which we have elsewhere paralleled with the upper portion of the Trenton Limestone (Mon. Sil. Foss. Girvan, p. 95). In Russia it was obtained by Dr. Dybowski from Herrküll, in beds of Ordovician age ("Borckholm beds" of Friedrich Schmidt). It has, however, recently been collected by one of us, in great quantity, in still lower beds in Esthonia, namely in the limestones of Saak, south of Reval. These limestones are placed by Magister Schmidt in the upper portion of the "Jewesche Schichten," and correspond, therefore, with the Trenton Limestone of North America. At this locality, *Solenopora compacta* not only occurs as detached specimens of all sizes, but it also makes up almost entire beds of limestone, most of the examples being in this case of comparatively small dimensions. Indeed, some of the bands of limestone at Saak look like amygdaloidal lavas; while others have a cellular appearance, from the dissolution out of them of the little pea-like skeletons of this fossil.

Apart, therefore, from the question of its affinities, *Solenopora compacta* must be regarded as remarkable both for its very wide geographical range, and also on account of its being highly characteristic of a definite geological horizon. As before mentioned, however, there are certain differences which separate the Scotch examples of the species from those found in other regions. The *type* of the species must be held to be the Canadian examples, since it was upon these that Billings founded his *Stromatopora compacta.* With the Canadian examples, the Russian examples appear to agree in every particular. On the other hand, the tubes in the Ayrshire specimens are decidedly, and apparently constantly, larger than those of the Canadian and Russian examples, their general structure being otherwise the same. This difference will be seen by comparing the tangential section of an Ayrshire example of *Solenopora compacta* (Pl. XIII. Fig. 3) with a corresponding section of a Russian specimen (Pl. XIII. Fig. 6), the two being drawn to the same scale. As above said, the Canadian specimens and the Russian are in this respect alike. It may, therefore, be as well to consider the Ayrshire specimens as constituting a variety of the species under the name of *Solenopora compacta*, var. *Peachii.*

EXPLANATION OF PLATE XIII.

Fig. 1. An example of *Solenopora compacta*, Bill. sp., from the Ordovician Limestone of Saak, Esthonia. Natural size.

„ 2. Vertical section of a specimen of *Solenopora compacta*, var. *Peachii*, Nich. and Eth. Jun., from the Ordovician Limestone of Craighead, Girvan. Enlarged about fifty times.

„ 3. Tangential section of the preceding, similarly enlarged. Both these sections show the fissiparous development of the tubes.

„ 4. Part of a long section of a specimen of *Solenopora compacta*, Bill., from the Trenton Limestone of Prince Edward's County, Ontario. (Coll. Dr. George J. Hinde.) Enlarged about one hundred and fifty times, and showing the curious concentric banding of the fossil.

„ 5. Tangential section of the preceding specimen, similarly enlarged.

„ 6. Tangential section of a specimen from Saak, Esthonia. Enlarged fifty times.

„ 7, 8. Tangential sections of another specimen from Saak, showing different conditions of preservation of the walls. Both sections show numerous septiform processes due to the fission of the tubes. Enlarged one hundred and fifty times.

„ 9. Part of a vertical section of *Solenopora compacta*, var. *Peachii*, enlarged fifty times, showing a true concentric line of growth. Craighead, Girvan.

„ 10, 11. Vertical and tangential sections of a recent Nullipore, enlarged one hundred and fifty times.

II.—Notes on the Carboniferous Ostracoda of the North-West of England.

By Professor T. Rupert Jones, F.R.S., and James W. Kirkby, Esq.

Introduction.

THE following notes and lists of species are based upon material collected by one of us during several visits to the neighbourhood of Grange-over-Sands, Lancashire. They are here recorded because they add a little to what is known of the distribution of Bivalved Entomostraca in the North-West of the English area during the early half of the Carboniferous Period.

The localities from which we obtained our material range over part of the Furness district, and the country to the north and north-west of Morecambe Bay. Most of this is in North Lancashire, but a portion of it lies in Westmoreland. The Sheets 98 S.E., 98 S.W., and 91 N.W. of the One-inch Map of the Geological Survey take in nearly the whole of this region.

The Carboniferous strata here represented are the Scar- or Mountain-Limestone and the Yoredale rocks. A little further to the west, in the valley of the Lune, the Millstone-grit and Coal-measures come in; but these we have not seen. The localities are therefore all in the lower half of the Carboniferous series.

The Scar-limestone is about 1000 feet in thickness, and is finely exposed in most parts of the district, in both natural and artificial sections. Generally speaking it is not rich in fossils; and, when they are present, they are difficult to extract owing to the hardness of the rock. Hence, with one exception, the Ostracoda have not been obtained from the limestone itself, but from the shaly partings, or intercalated thin beds of shale, that are occasionally (though rarely) present in it. Most of these more argillaceous bands appear to come in near the base of the Limestone, as at Arnside, Sandside, and Heversham; but there is one bed (perhaps more) of shale somewhere near its centre, as at Kendal, Kent's Bank, and Stainton. In one locality, near Storr Moss, the limestone, just beneath the turf, was somewhat decomposed and pretty full of Entomostraca, which were easily got out.

The Yoredale rocks are not well seen, and we have been able to examine only one good natural section of them (Holker Park). In Furness, where they have been proved to be of considerable thickness, they are usually covered by superficial deposits, and thus not easily to be got at, except where brought to the surface by the sinking of ironstone-pits and wells, or where quarries and railways have cut into them. The presence of this series of beds in Furness was, we believe, first noticed by the Survey Geologists; and it may be here mentioned that the maps and memoirs which they have published on this region have been of considerable service to us in examining the district for Ostracoda.

In working the shales for these microzoa, we have followed the usual method of washing (or boiling) away the earthy matter from the organic contents of the different samples collected, and sorting what is left by sifting, preparatory to picking out the Entomostraca with a watch-maker's lens and sable pencil.

Besides Ostracoda, most of our washings contain Foraminifera; and some of those from the Yoredale rocks are rich in Polyzoa;[1] the latter especially in the shales from Holker Park and Gleaston Castle.

The marks * and ** prefixed to the species in the following lists indicate their relative local abundance.

I.—LOCALITIES IN THE SCAR-LIMESTONE.

1. *Arnside.*—The best locality we have met with for Ostracods in the Scar-limestone is near to Arnside, where what appears to be the lowest beds of the series come up, on the shore, half a mile to the west of the village. These beds have shaly partings, and in some places become decidedly argillaceous in character. From various washings of the softer portions we have obtained the following species,—associated with Foraminifera, Polyzoa, Crinoids, and a few Brachiopods :—

**Leperditia Okeni* (Münster).
L. suborbiculata (Münster).
L. oblonga, J. & K.
L. acuta,[2] J. & K.
L. obesa, sp. nov. MS.
**Beyrichia craterigera*, G. S. Brady, MS.
B., sp.
**Kirkbya umbonata* (D'Eichwald).
K. tricollina, sp. nov. MS.
***Cytherella valida*, J. K. & B.

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[1] The Polyzoa met with have been handed to Mr. G. R. Vine.

[2] This was originally published as *L. Okeni*, var. *acuta;* but we now prefer to give this and some other forms a specific, instead of a varietal standing.

Cytherella scrobiculata, J. K. & B.
**Cythere* ?[1] *cuneola*, Jones & Kirkby.
C. ?[1] *gyripunctata*, sp. nov. MS.
Bythocypris Phillipsiana, Jones & Holl, var. *carbonica*, nov.
Argillœcia œqualis, J. & K.
Macrocypris Jonesiana, Kirkby.

**Bairdia Hisingeri* (Münster).
**B. curta*, M'Coy.
**B. plebeia*, Reuss, var.
B. ampla, Reuss.
B. brevis, J. & K.
**B. subelongata*, J. & K.
***B. submucronata*, J. & K., and var.

2. *Sandside.*—The species given below are from soft shaly partings in the limestone that is exposed on the roadside between Sandside Station (Kendal Branch of the Furness Railway) and Arnside, southward of the bridge that carries the road over the line. Entomostraca are moderately plentiful, and are associated with a few Crinoids and other fossils.

Leperditia Okeni (Münst.).
L. sp.
Kirkbya umbonata (D'Eichw.).
K. costata (M'Coy).
***Cytherella valida*, J. K. & B.
C. scrobiculata, J. K. & B.
C. recta, J. K. & B.

**Cythere* ?[1] *cuneola*, J. & K. MS.
Bythocypris bilobata (Münst.).
Cythere ?[1] *subreniformis*, Kirkby.
***Bairdia Hisingeri* (Münst.).
B. plebeia, Reuss, var.
**B. subelongata*, J. & K.
B. amputata, Kirkby.

3. *Heversham.*—In a cutting on the Kendal Branch of the Furness Railway. From shaly partings of a dark-grey limestone, apparently low down in the Scar-limestone. The fossils associated are Corals, Crinoids, and Brachiopods. Entomostraca are rather rare.

Leperditia Okeni (Münst.).
Kirkbya umbonata (D'Eichw.).
K. costata (M'Coy).
**Cytherella valida*, J. K. & B.
C. scrobiculata, J. K. & B.

Cythere[1] ? *cuneola*, J. & K. MS.
**Bairdia Hisingeri* (Münst.).
B. plebeia, Reuss, var.
**B. submucronata*, J. & K.

4. *Kettlewell Quarry, Kendal.*—Our attention was kindly directed to this locality by Mr. Severs, of Kendal. The quarry is on the hill a little to the north-west of the town, where the limestone has been worked for lime-burning. A bed of shale, a foot or so thick, is here exposed, and in it the remains of Ostracoda are not at all rare, though badly preserved. The four following species have been determined; some specimens, which we cannot make out, may represent other forms.

Leperditia Okeni (Münst.).
Beyrichia radiata, J. & K.

Cytherella valida, J. K. & B.
Bairdia submucronata, J. & K.

5. *Meathop.*—This locality is just to the north of the Grange Gasworks, by the side of the road to Meathop, where the limestone cliff is occasionally quarried for road-metal. The lower beds have argillaceous partings, one of which swells into a bed of shale fully a foot thick. This evidently local bed is filled with the remains of *Kirkbya spiralis*, J. & K., along with a few valves of *Leperditia Okeni* (Münst.). No other fossils have been noticed; nor have we observed these or other Entomostraca elsewhere hereabouts.

6. *North of Storr Moss, Silverdale.*—In limestone just to the north of Storr Moss, as seen by the side of the road from Silverdale to Yealand-Redmayne, and about a mile from the railway station. Just

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[1] The generic relationship of the species thus marked in these lists is doubtful as yet; certainly they are not true *Cytheræ*.

under the turf the limestone is rather rotten, and full of Corals and Mollusca; Ostracoods also are plentiful, and as follow—

**Leperditia Okeni* (Münst.).
**L. Armstrongiana*, J. & K. MS.
Beyrichia radiata, J. & K.
***Kirkbya Permiana*, Jones.
Cytherella ? reticulosa, sp. nov. MS.
**Cythere*[1] *? cuneola*, J. & K.
**Xestoleberis ? subcorbuloides*, sp. n. MS.
**Bythocypris bilobata* (Münst.).
Argillœcia æqualis, J. & K. MS.
Bairdia Hisingeri (Münst.).
B. ampla, Reuss.
**B. curta*, M'Coy.
***B. brevis*, J. & K.

7. *Kent's Bank.*—From a bed (about a foot thick) of very dark, shivery shale in the limestone cutting on the Furness Railway, a little to the west of Kent's Bank Station. The shale is exposed on both sides of the cutting; also close to the sea-shore, immediately to the south. The associated fossils are species of *Productus* and other Brachiopods, etc. Ostracoods are few.

Leperditia Okeni (Münst.).
Beyrichia, sp.
Cytherella, sp.
Bairdia Hisingeri (Münst.).
B. submucronata, J. & K.

8. *Stainton.*—In Stainton Quarry, a mile or so south-east of Dalton-in-Furness, *Kirkbya Permiana* occurs in shaly partings of the Scar-limestone, associated with Corals.

II.—Localities in the Yoredale Rocks.

1. *Humphrey Head.*—On the west side of Humphrey Head, just to the south of the Holy Well, is about four feet of grey shale, associated with limestone in thinnish beds, and lying rather irregularly with a steep dip to the west. Both shale and limestone are fossiliferous, and we take them to be Yoredale beds faulted down against the cliff of Scar-limestone forming this picturesque headland.[2]

Leperditia Okeni (Münster).
Beyrichia radiata, Jones & Kirkby.
**B. ? ventricornis*, J. & K. MS.
Kirkbya Permiana, Jones.
**K. Urei*, Jones.
Cytherella Bennieі, J. K. & B.
Cythere ? cuneola, J. & K. MS.
**C. ? cornigera*, J. & K. MS.
Bairdia Hisingeri (Münst.).
**B. plebeia*, Reuss.
**B. submucronata*, J. & K.
B. brevis, J. & K.
B. sp.

2. *Holker Park.*—An interesting section of the Yoredale rocks is exposed on the west side of Holker Park, just on the edge of the marshland to the north of Quarry Flat. These beds consist of yellow sandstones, shales, and crinoidal limestones, all dipping sharply about south-south-east. A few Ostracods are found in a dark-grey shale underlying the uppermost limestone; but they are not numerous, and are very badly preserved. A little further to the north a thick calcareous shale comes in beneath another and lower limestone. This shale is especially rich in Polyzoa besides other fossils. Twelve species of Ostracoda occur in it, all of small size, and none very plentiful.

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[1] See footnote 1, ante p. 537.

[2] In the One-inch Map of the Geological Survey no Yoredale beds are shown here; but this is probably due to their having been only recently exposed.

Leperditia acuta, J. & K.
Beyrichia, sp.
**Kirkbya Urei*, Jones
K. spinosa, J. & K.
Cytherella valida ?, J. K. & B.
C. recta, J. K. & B.
C. scrobiculata, J. K. & B.
**C.*[1] *? cuneola*, J. & K. MS.
**Bairdia plebeia*, Reuss.
B. brevis, J. & K.
B. subelongata, J. & K.
B. sp.

3. *Little Urswick.*—At the waste-heaps of an abandoned ironstone-pit, in a field just to the east of Little Urswick, Furness, are quantities of a light-grey and reddish shale, containing a few Ostracods. The shale belongs to the Yoredale series, and is full of Crinoidal stems, with *Fenestella* and other Polyzoa, and Molluscan fossils. Fragments of a similar shale are seen on some waste ground, by the side of the road, just to the south-east of the village. This material looks like a very suitable rock for Ostracoda, but several boilings of it have only yielded the following species :

Leperditia Okeni (Münst.).
Bythocypris bilobata (Münst.).
**Bairdia plebeia*, Reuss.
Bairdia subelongata, J. & K.
B. brevis, J. & K.
B. sp.

4. *Scales Green.*—An exposure of dark shale is seen on the north side of the pond (the water being low) at Scales Green, at the east end of the village of Scales, in Furness. Crinoids and other marine fossils are common in the shale, which apparently belongs to the Yoredale series, though the ground is coloured as Carboniferous Limestone in the One-inch Map of the Geological Survey. The Ostracoda are small and not very plentiful:—

Beyrichia radiata, J. & K.
B. ? ventricornis, J. & K.
**Cythere ? cuneola*, J. & K. MS.
**C. ? cornigera*, J. & K. MS.
Bairdia plebeia, Reuss.
B. brevis, J. & K.
**B. submucronata*, J. & K.

5. *Gleaston Castle.*—The species mentioned below are from the shaly partings of a dark-grey limestone seen in an old quarry on the east side of the road a little to the north of Gleaston Castle, in Furness. The position of the limestone is said by the Geological Survey authorities[2] to be at about the base of the Yoredale Rocks. The shale is rich in fossils, especially in Polyzoa.

**Cytherella valida*, J. K. & B. var. *affiliata*, nov.
**Phreatura concinna*, gen. et. sp. n. MS.
**Bairdia Hisingeri* (Münst.).
**B. plebeia*, Reuss.
**B. brevis*, J. & K.
Bairdia subelongata, J. & K.
B. ampla, Reuss.
**B. submucronata*, J. & K.
B. legumen, sp. nov. MS.

6. The only other locality where we have found Entomostraca is in pebbles from the Drift, as seen on the coast to the north of Aldingham. In one of these *Kirkbya Permiana*, Jones, was peculiarly abundant, as good impressions. Species of *Cythere* and *Bairdia* occurred with it.

In the accompanying Table the distribution of the species in the Scar-Limestone and Yoredale Rocks is shown, as well as their occurrence elsewhere in the North of England and in Scotland.

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[1] See footnote 1, ante p. 537.
[2] Explanation of Quarter Sheet 91 N.W., p. 8.

TABLE OF SPECIES SHOWING THEIR DISTRIBUTION.

Species.	N. Lancashire and Westmoreland.		Northumberland, etc.[1]	Scotland.	
	Scar-limestone.	Yoredale Rocks.		L. Carboniferous.	Carbonif. Limestone Series.
Leperditia Okeni (Münster)	x	x	x	x	x
L. suborbiculata (Münst.)	x	...	...	...	x
L. oblonga, Jones & Kirkby.........	x	...	...	...	x
L. acuta, J. & K.	x	x	x	...	...
L. Armstrongiana, J. & K. MS....	x	...	...	...	x
L. obesa, sp. nov.	x	...	...	...	...
Beyrichia radiata, J. & K.	x	x	x	x	x
B. sp.....................................	x	...	...	...	...
B. craterigera, Brady, MS.	x	...	x	...	x
B. ventricornis, J. & K. MS.	...	x	...	...	x
Kirkbya Permiana, Jones	x	x	x	x	x
K. umbonata (D' Eichwald).........	x	...	x	x	x
K. tricollina, sp. nov.	x	...	...	...	...
K. costata (M'Coy)	x	...	x	x	x
K. spiralis, J. & K.	x	...	...	x	...
K. Urei, Jones	...	x	x	...	x
K. spinosa, J. & K.	...	x	x	...	x
Cytherella valida, J. K. & B.	x	?	x	...	...
——— ——— var. *affiliata*, nov.	...	x	...	...	...
C. scrobiculata, J. K. & B.	x	x	x	...	x
C. recta, J. K. & B.	...	x	x	...	x
C. Bennici, J. K. & B., var.	...	x	x	...	...
C. sp.	...	...	...	...	...
C. ? reticulosa, sp. nov...............	x	...	x	...	?
Bythocypris bilobata (Münst.).....	x	x	x	x	x
B. Phillipsiana, Jones & Holl, var. *carbonica*, nov.	x	...	x	..	x
Argillæcia æqualis, J. & K. MS....	x	...	x	x	...
Macrocypris Jonesiana, Kirkby ...	x	...	x	x	...
Xestoleberis ? subcorbuloides, sp.nov	x	...	...	...	...
Phreatura concinna, gen. & sp. nov.	...	x	...	...	...
Bairdia Hisingeri (Münst.).........	x	x	x	x	x
B. plebeia, Reuss.	x	x	x	x	x
B. curta, M'Coy	x	...	x	...	x
B. ampla, Reuss.	x	x	x	x	x
B. brevis, J. & K.	x	x	x	x	x
B. submucronata, J. & K.	x	x	x	x	x
B. subelongata, J. & K.	x	x	x	x	x
B. amputata, Kirkby	x	...	x	...	...
B. legumen, sp. nov....................	...	x	...	...	?
Cythere ? cuneola, J. & K. MS....	x	x	x	...	x
C. ? cornigera, J. & K. MS.	...	x	x	...	x
C. ? gyripunctata, sp. nov.	x	...	...	...	...

Note.—We hope to have an early opportunity of describing and figuring the new species.

Of this list 24 species occur elsewhere in the Carboniferous rocks of the North of England. And 28 of them are known to us from Scotland. Two others (*Cytherella ? reticulosa* and *Bairdia legumen*) are also probably found there. Five species—*Leperditia obesa*, *Kirkbya tricollina*, *Phreatura concinna*, *Xestoleberis ? subcorbuloides*, and *Cythere ? gyripunctata*—are new to us.

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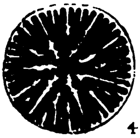
[1] Including a few localities in Durham and Cumberland.

Geol. Mag. 1885. Decade III. Vol. II. Pl. XIV.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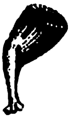
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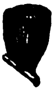
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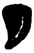
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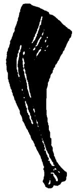
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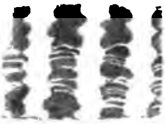
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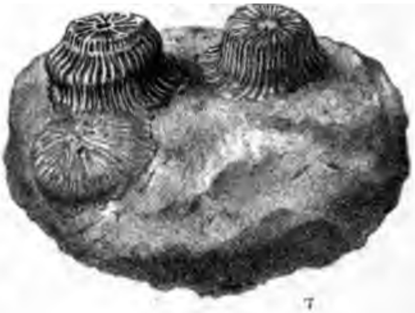
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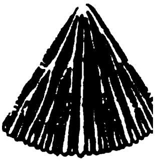

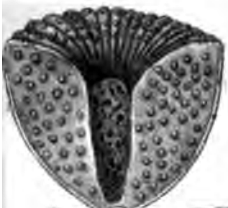
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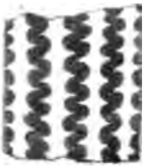
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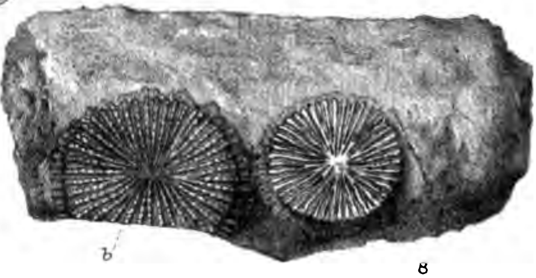

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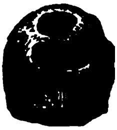

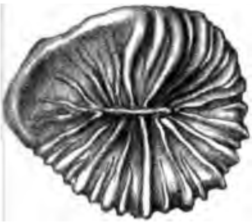
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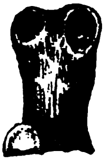
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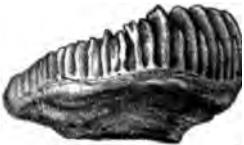
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C. Berjeau lith. R. F. Tomes del. West, Newman & Co. imp.

British Cretaceous Madreporaria.

As common Scar-limestone forms the following may be taken:—*Leperditia Okeni*, *Kirkbya Permiana*, *Cytherella valida*, *Bairdia Hisingeri*, and *B. submucronata*. As distinguishing species, on account of their exceptional occurrence in this formation, may be also named *Leperditia Armstrongiana*, *L. obesa*, *Beyrichia craterigera*, *Kirkbya costata*, *K. spiralis*, *K. tricollina*, *Bythocypris bilobata*, *Argillœcia æqualis*, *Bairdia curta*, as well as others, most of which are either confined to or attain their maximum development in the Lower Carboniferous series of Scotland and the North of England.

The Ostracoda of the Scar-limestone are generally more plentiful and robust than those in the "Yoredales" above. *Bairdia Hisingeri* particularly is large and thick-shelled as well as common. *Cytherella valida* is perhaps the most abundant of any form in the shale and shaly partings of the lowest beds. In the limestone itself, *Leperditia Armstrongiana*, *Bythocypris bilobata*, *Bairdia curta*, and *Xestoleberis? subcorbuloides* come to the front as relatively common forms.

In the Yoredale beds 22 species occur, most of which are of poor growth and scarce, as before said. *Beyrichia ventricornis*, *Kirkbya Urei*, *Cythere? cuneola*, *Bairdia plebeia*, and *B. brevis* may be named as the prevailing forms. The two first named, along with *K. spinosa*, *Cytherella recta*, *C. Benniei*, *C.? cornigera*, and *Phreatura concinna*, are apparently confined to this formation. All of these, except the last (which is new), are well-known forms in the Carboniferous Limestone series of Scotland, which formation is equivalent in part to the Yoredale beds.

In conclusion, we may add that there is little doubt but that more remains to be done in this district, and it would be well if the subject were taken up and thoroughly worked out by some one residing in the locality.

III.—Observations on some imperfectly known *Madreporaria* from the Cretaceous Formation of England.

By Robert F. Tomes, F.G.S.

(PLATE XIV.)

THE arrangement of a considerable collection of Cretaceous corals in my own cabinet has been the means of identifying some species not hitherto recorded as English, though well known elsewhere, and at the same time of subjecting some others to a more searching examination than they had before undergone. The result has been the addition of the following genera to the English list, viz. *Ceratotrochus*, *Pleurosmilia*, *Barysmilia*, *Rhizangia*, and *Leptophyllia*.

A very careful examination of the corals of the Red Chalk of Hunstanton has brought to light some affinities which have been wholly overlooked, and which have occasioned their removal into quite a different genus from the one in which they were placed by their original describer. Similarly the genus *Turbinoseris*, from the Lower Greensand of Atherfield, is now absorbed into an earlier formed genus.

A section of the Gault at Folkestone is given, not from any new features it contains, but to afford the opportunity of pointing out the exact stratigraphical position of the several species of *Madreporaria* there met with.

SECTION OF THE GAULT AT FOLKESTONE.

	ft.	in.	
1. Rubbly yellow Gault............about	39	0	*Pecten*, *Astrea*, *Hamites*, *Ammonites Goodhalli*.
2. Light-coloured mottled Gault, with layers of phosphate nodules about the middle, and a hard seam near the bottom, with a layer of Nodules beneath it	22	0	*Ammonites cristatus*, *Pentacrinus Fittoni*.
3. Inoceramus bed, blue Gault, with a hard seam in the middle............	9	0	Casts of *Inoceramus* above the hard seam—*Trochocyathus Wiltshirei*, *Caryophyllia Bowerbanki*.
4. Nodule bed	5	0	*Trochocyathus Harveyanus*, and a variety, *Bathycyathus Sowerbyi*.
5. Very dark Gault with a hard seam at the bottom	7	0	
6. Dark mottled bed	3	0	
7. Light mottled bed, in the bottom of which are many corals	6	0	Fucoids, *Nautilus*, *Gervillea*, *Ceratotrochus insignis*, *Smilotrochus cylindricus*, *S. calcaratus*, *Leptocyathus gracilis*.
8. Light fawn-coloured bed............	7	0	Crustacea, *Pinna*.
9. Very dark Gault	5	0	*Mytilus*, *Trochocyathus Harveyanus*.
10. Gault	5	0	*Cyclocyathus Fittoni*.
11. Gault, containing bands of nodules of sulphate of iron	6	0	
12. Dark-coloured Lower Greensand, said to contain corals.			

The foregoing section was copied by me from one in the possession of the well-known collector of Gault fossils, Mr. J. Griffiths, of Folkestone, whose practical knowledge of the locality is very intimate. This was taken to the spot, and made use of in fixing the position of the corals. It has subsequently been correlated with the one published by Mr. Price in the Quarterly Journal of the Geological Society.[1] I regret that I did not consult Mr. Price's section before visiting the coral-bearing strata at Folkestone, as I should have referred to it instead of the one I have here introduced. A great many of the species were observed *in sitû*, and were placed in the section on the spot. Nearly all the corals I saw were in a thin seam between beds number 7 and 8. The common species, *Cyclocyathus Fittoni*, is not, however, by any means confined to the one bed mentioned, but has a vertical range of nearly fifty feet. Probably also *Trochocyathus Harveyanus* has a somewhat similar range.

CERATOTROCHUS INSIGNIS, Dunc. sp. Pl. XIV. Fig. 6.

Smilotrochus insignis, Dunc. Supp. Brit. Foss. Cor. pt. ii. p. 37, pl. xvi. fig. 18, 1870.

Having been struck with the very great resemblance between the *Smilotrochus insignis* of Duncan and the *Ceratotrochus ornatus* of M. de Fromentel, I broke up some specimens of the former, from the Gault of Folkestone, and ascertained at once, by the existence of a large and spongy columella, that I had very properly suspected both of being representatives of the same genus. Prof. Duncan's species must therefore be removed into the genus *Ceratotrochus*, and that genus must now be introduced into the English Coral fauna. The specific resemblance between the two above named is so considerable that some suspicion may well be entertained as to their distinctness, but there are some particulars in which they differ. The English form has the columella smaller, and the septa and mural costæ are much more uniform in size throughout. Moreover, the single row of tubercles which ornaments the costæ in both species are much smaller in the English than in the French specimens. However, they are very closely allied forms, and the one may very possibly prove to be only a variety of the other.

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[1] Quart. Journ. Geol. Soc. 1874, vol. xxx. p. 342.

TROCHOCYATHUS WILTSHIREI, Dunc. Supp. Brit. Foss. Cor. pt. ii. p. 34, pl. xiv. figs. 10–12, 1870.

Smilotrochus granulatus, Dunc. *loc. cit.* p. 36, pl. xiv. fig. 17.

The existence of a columella in the supposed *Smilotrochus insignis*, and its consequent removal to another genus, naturally led to the search for a columella in the allied species *Smilotrochus granulatus*. The result was the discovery of that part surrounded by pali. A subsequent investigation of the coralla of many species of varied ages satisfied me that none of them are anything more than immature examples of the species described by Prof. Duncan under the name of *Trochocyathus Wiltshirei*.

I may add that in the investigation of these small *Madreporaria* from Folkestone, it is absolutely necessary that a good many examples should be examined, and that some of them should be broken up, otherwise their real affinities will be overlooked, as they appear to have been by Prof. Duncan.

Some of the immature examples of this species have so close a resemblance to specimens of the foregoing species, which are of corresponding size, that it is impossible to distinguish them, excepting by ascertaining whether they have pali or not.

SMILOTROCHUS ? CALCARATUS, sp. nov. Pl. XIV. Figs. 1–5.

The corallum is small, conical, and the inferior extremity is produced into a long oblique and slender, but flattened, spur, which, when complete, has a ring of short rootlets at the end, by which it may perhaps have been attached.

The mural costæ are distinct, rather large, equal in size, rounded, and prominent according to their order. They are continued along the spur, quite to the end. They have a single row of tubercles along their central line, which are most distinct near the calice, more especially in young specimens. In the larger, and therefore older ones, the tubercles are nearly obsolete.

The calice is circular, saucer-shaped, and the margin is rather thin. The septa are a little exsert outwardly, near the margin of the calice, but speedily curve inwards and downwards towards the fossula.

There are six systems, and four complete cycles, and a fifth which is incomplete.

Those of the first cycle are long, and approach very near to the axial space, and their lateral spines, which are scarcely observable near the wall, gradually increase in size and prominence towards their inner margin, where they are much pronounced and have a rugged nodular growth. The septa forming the second cycle are three-fourths the length of those of the first, and are similarly furnished with rugged and warty processes (spines?) at their inner margins. The third cycle has septa which are three-fourths the length of those of the second, and which have also similar excrescences at their inner margin, and the fourth is formed by septa which are scarcely half the length of the third, while those of the fifth cycle are very short, simple, and irregular, and even absent in some of the systems. The spinous processes of the septa, which are confined to the first three cycles, have sufficient prominence and irregularity of growth to mix and form a loose mass, which occupies the whole of the middle part of the calice. There is considerable irregularity in the degree of development of this in different examples, and in some of them it fills up the calice so much that the cycles are difficult to trace. I have examined fifteen specimens of this species from the Gault of Folkestone, not one of which has the margins of the septa uninjured, while the calice of most of them is much damaged by pyrites. A single specimen from the Speeton clay of Yorkshire has also come under my observation. It is a small one, and the oblique foot and the peculiar septal processes are not greatly developed.

The height of the largest specimen I have seen is a little more than half an inch, and the diameter of the calice three lines.

It is with considerable doubt that I place this curious species in the genus *Smilotrochus*.

CYCLOCYATHUS FITTONI, var.?

Micrabacia Fittoni, Duncan, Suppl. Brit. Foss. Cor. pt. ii. p. 37, pl. xiv. figs. 6-9, 1870.

More than twenty years ago I received from the late Dr. S. P. Woodward a small collection of corals from the Gault of Folkestone, in which was a specimen which, though labelled by him *Cyclocyathus Fittoni*, appeared to differ from all the others which were similarly named, and from the same locality. It corresponds in every particular with *Micrabacia Fittoni*, Duncan, and, like the figured specimen, had the whole of the central region obscured by stony matter. Fortunately the usually troublesome and destructive pyrites was absent, and black and apparently phosphatic lime, though hard, gave way to and was readily scooped out by a sharp steel instrument, and a deep calice revealed. In this is a papillous columella and a ring of pali. These are seen in section, and being of a pure white colour, are very clearly defined by the surrounding black substance with which the loculi are filled. Compared with the same parts in *Cyclocyathus Fittoni*, they correspond very closely, and all further question about the generic affinities of the species under consideration is set at rest. There is, however, one peculiarity about which I am by no means satisfied. I allude to the single layer of dissepiments which is visible a little above the basal wall, all round the corallum, like a tabulum. It is well figured by Prof. Duncan, who speaks of it as consisting of large synapticulæ. But that it is dissepimental in its nature I have not the least doubt, the downward curvature in each loculus being only what is observable in the dissepiments of some *Montlivaltiæ*, though in that genus they are never arranged so as to form a tabulum. I may also allude to the great flatness of the whole of the under surface, and of the costæ, as well as the regularity in the size of the latter, as differing from the same parts in typical specimens of *Cyclocyathus Fittoni*. It cannot, however, be considered as anything more than a variety of that species, and of course the existence of this second species of *Micrabacia* is inadmissible.

BARYSMILIA TUBEROSA, Reuss. Beitr. Charak. Kreid. Ostalpen, p. 91, pl. x. figs. 14—15, 1854, Deuts. K.K. Akad. Wien, vii. Pl. XIV. Fig. 15.

A species of *Barysmilia* from the Upper Greensand of Haldon has long been known to me. A specimen in my own cabinet, though of small size, agrees so nearly with the description and figure given by Reuss of *Barysmilia tuberosa*, that there can be no doubt as to its identity with that species. The calices in this specimen are rather more irregular in form and are more closely placed than they appear in the figure alluded to. The small size of this and the following species, compared with the examples figured by their respective describers, is in accordance with the stunted form of other compound corals from the same locality, though some of the simple ones are of relatively greater size.

BARYSMILIA CORDIERI, M. Edw. and Haime. Ann. des Sci. Nat. 3rd ser. t. x. p. 273, pl. 5, fig. 4, 1849. E. de From. Pal. Franç. Polyp. Terr. Crétacé, p. 385, pl. 86, fig. i. 1873. Pl. XIV. Fig. 14.

In the elevated and almost cylindrical form of the peduncular parts of the corallum, in the ovoid or round and comparatively small size of the calices, and in the number and delicacy of the mural costæ and septa, the only specimen yet obtained agrees closely with the figure and description of *Barysmilia Cordieri* of MM. Milne Edwards and Haime. But while the figure above mentioned represents a corallum of four inches in height, the specimen now before me is only one inch high. This specimen was obtained from Haldon with the last species. No locality is assigned to the present species by MM. Milne Edwards and Haime, but M. de Fromentel, who copies their figure, mentions its occurrence in the Craie tuffeau of Mamers (Sarthe).

Some other compound corals have been collected at Haldon, which from their unsatisfactory condition cannot be determined, though I believe them to be new. As the Haldon corals are only casts, they cannot be trusted when internal structure is important. The genus *Haldonia* is in my opinion a very doubtful one. Specimens in my own collection from Haldon differ in the important respect of sometimes having a styliform columella, and sometimes only a ring of pali, as in Prof. Duncan's figures.

The very dwarfed individuals representing the two species of *Barysmilia* from Haldon are apparently in exact accordance with the small and incrusting *Thamnastrææ* from the same locality.

Genus PLEUROSMILIA, E. de From. Bull. de la Soc. Géol. de France, 2nd ser. t. xiii. p. 853, 1856.

The generic name *Pleurosmilia* was first made use of in 1856 by M. de Fromentel for a group of simple corals having an elongated and essential columella, one end of which is united to one of the principal septa, and the other end is free.[1] The specimens on which the genus was first founded were obtained from the Portland Oolite of France (Haute Saône), where a species of *Peplosmilia*, to which *Pleurosmilia* is allied, also occurs. In the subsequently published Paléontologie Française,[2] the same distinguished Zoophytologist described and figured two other species, under the names of *Pleurosmilia Neocomiensis* and *P. Barrottei*, both from the Neocomien formation of Chatouroupt, Haute-Marne, France.

Without entering into any of the considerations affecting the correlation of the Greensand of this country with the Neocomien of the Continent, it will be interesting to add to the palæontological evidence already known and recorded, the occurrence in the Isle of Wight of one of the above-mentioned species, described and figured by M. de Fromentel from the Neocomian strata of France.

PLEUROSMILIA NEOCOMIENSIS, E. de From. Pal. Franç. Terr. Crétacé, p. 375, pl. 78, fig. 1. Pl. XIV. Figs. 12 and 13.

One specimen only of *Pleurosmilia neocomiensis* has, as yet, been met with, so far as I know, and it was taken from the "Perna beds" of the Lower Greensand at Atherfield, Isle of Wight. It possesses all the characteristics of the species in a well-marked degree. The shortness of the corallum, the elongated form of the calice, the stoutness of the septa, and the rugose epitheca, are peculiarities, the presence of which leaves no doubt as to the identity of our English specimen with those figured by M. de Fromentel.

Professor Quenstedt has proposed that the name *Axophyllum* should be substituted for that of *Pleurosmilia*, but the latter for obvious reasons must be retained.

ASTROCŒNIA, sp.

A single ill-preserved specimen of a small species of *Astrocœnia*, which was obtained from the well-known locality for Greensand fossils at Farringdon, has fallen into my hands. The base is quite flat, and the upper surface hemispherical. The calices are crowded and have a diameter of about one line. It is not in a sufficiently good state of preservation to admit of satisfactory specific definition, though it possesses characters which do not correspond with those of any species of *Astrocœnia* which I have yet met with.

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[1] Bull. de la Soc. Géol. de France, 2nd ser. 1856.

[2] Terr. Crétacé Zooph. p. 375-6, pl. 78.

ISASTRÆA REUSS[I]ANA, M. Edw. & Haime. Hist. Nat. Corall. ii. p. 528.

Ulophyllia crispa, Reuss. Denkschr. der Akad. der Wiss. Wien, t. vii. p. 106, pl. ii. fig. 6, 1854. (Not Milne Edwards and Haime).

In the collection of Cretaceous Corals in the British Museum are specimens of a coral, some of which have been obtained from Atherfield, Isle of Wight, and others from Gosau. They are without doubt specifically identical. Those from Gosau are labelled *Isastræa Reussana*, Milne Edwards and Haime, which is the *Ulophyllia crispa* of Reuss. The specimens from Gosau differ however from the figure given by Reuss in having their septa denticulated. The septa pass quite uninterruptedly from one calice to another, though there is a distinctly elevated line where the union of the calices takes place. Gemmation occurs freely between, or just within the calices, as in *Isastræa* and *Latimæandra*. The general aspect of this coral is very much that of a *Thamnastræa*, though on those parts of the corallum where increase in the number of calices has been the result of recent gemmation, a very Latimæandrine appearance is observable.

A broken specimen shows well-marked dissepiments, and imperfectly developed pseudo-synapticulæ, as in *Thamnastræa*. In another specimen there is an abundance of well-formed synapticulæ of a similar kind.

Leaving the identification and nomenclature of this somewhat obscure species for future consideration, I must content myself with observing of the Atherfield specimens that they, as well as the Gosau examples, have both dissepiments and synapticulæ.

ISASTRÆA NEOCOMIENSIS, sp. nov.

A specimen of a coral referable to the genus *Isastræa* forms part of the British Museum collection, and was obtained from the "Crackers beds" of the Upper Neocomian deposits of Atherfield, Isle of Wight. It bears some general resemblance to the *Isastræa profunda* of Reuss, but differs from it in some important particulars. The calices are larger and shallower, and the septa of one calice pass over the mural region and are continuous with those of adjoining calices. So far as I can observe, this does not occur in the species figured by Reuss. The specimen is very broadly attached (by the whole of its breadth) to a large specimen of *Perna Ricordeana*, D'Orbigny.[1] The upper surface is convex, and the outline considerably resembles that of *Isastræa profunda*. Around the outer margin is a fringe of short but well-defined radiating costæ, indicative of further extension of the corallum over the surface of the shell. The calices are distinctly polygonal, and where they are worn, the dividing wall becomes very apparent. The septa are thin, regularly denticulated, and some of the newer run into the older ones. The cycles are not traceable on account of the centre of the calices being more or less filled up with extraneous matter, but there are about forty septa.

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[1] I am indebted to the kindness of Mr. R. Bullen Newton, F.G.S., for the determination of this shell, and for other information which has enabled me to give the stratigraphical position of the coral here described.

The continuity of the septa between the calices of this species gives it a somewhat *Thamnastræa*-like aspect, which is suggestive of the presence of pseudo-synapticulæ. These, however, I have been unable to detect.

Diameter of the corallum, about 1 inch 9 lines.
Height of the corallum, about 11 lines.
Diameter of the calices, from 1½ to 2 lines.

Genus Rhizangia, Edw. and Haime, 1848.

Podoseris, Duncan, 1869.

My acquaintance with the corals of the Red Chalk dates from 1862, when, with other members of the British Association, then met at Cambridge, I visited Hunstanton and secured a considerable number of specimens. At that time I observed the peculiarly expanded base, with its ragged outline, suggestive of incompleteness, which characterizes so many specimens. Again in 1876, when a considerable collection of these small corals came into my possession, I was similarly impressed with the appearance presented by the peculiar conformation of the base, notwithstanding that Prof. Duncan had in the interval made the species the type of a new genus, under the name of *Podoseris*. But it was not until the kindness of Dr. W. Bölsche had furnished me with specimens of *Rhizangia Sedgwicki*, from the Cretaceous deposits of Gosau, that the real affinities of the Hunstanton corals became manifest, and their identity with *Rhizangia* established.

The comparison of the Hunstanton corals with undoubted examples of that genus, besides detecting characters which have led to the generic alterations here made, has also been the means of discovering some other peculiarities which deserve mention. The endotheca of the species described by Prof. Duncan under the names *Podoseris mamilliformis* and *Podoseris elongata* is peculiar, and cannot be understood without the assistance of vertical and horizontal sections.

The septa, like those of *Cyclolites* and *Leptophyllia*, are formed by vertical trabiculæ, having schlerenchimatous expansions at regular intervals, constituting horizontal ledges, which are on the same level on each side of the septum, but are not opposite those of other septa, and they do not meet in the middle of the loculus. Dissepiments are present, but they are peculiarly arranged. At nearly regular intervals from the base of the corallum upwards, there are thick and rudely-formed layers of endotheca, which are of a dissepimental nature. They extend in all the loculi across the whole of the corallum, on nearly the same level, and are formed by the crowding together of numerous thin and flat dissepiments. Their position in the corallum is indicated in Prof. Duncan's figure of *Rhizangia elongata*. (Supp. Brit. Foss. Cor. pt. ii. pl. ix. fig. 16). Magnified representations of the same are also given in Figures 9 and 11 of Plate XIV. accompanying the present paper.

So far as I have been able to observe, there is no true wall, only such a one as would be formed by the union of synapticulæ near the outside of the corallum. Beyond this so-formed wall the ends of the septa project, and unless hidden beneath bands of irregularly developed pellicular epitheca, synapticulæ may be seen between them.

I am not at present familiar with the endotheca of any species of *Rhizangia*, excepting the species here mentioned, and am indeed prepared to learn that it has not yet received attention at the hands of zoophytologists. So far, however, as may be gathered from an inspection of the figures of some of the species, there are indications of a septal structure corresponding with what I have above described. The denticulations of the septa of such species as *Rhizangia procurrens*, Reuss,[1] bear but little resemblance to those of any of the *Astræidæ*. They more nearly correspond with the denticulations of the septa of some of the *Fungidæ*, and are probably the terminations of vertical trabiculæ, loaded by a synapticular growth, as in *Cyclolites* and *Leptophyllia*.

To the genus *Podoseris*, first formed for the reception of these Red-Chalk corals, another species from the Inferior Oolite of Dorsetshire has been added by Professor Duncan. This is *Podoseris constricta*, the type of which has lately been in my hands. The examination of it and of some other corals from the same bed has convinced me that it is nothing more than an abnormal form of a species appertaining to an old and well-known genus.

The genus *Syzygophyllum* of Reuss appears to me to possess some characters which are not wholly inconsistent with those of *Rhizangia*.[2] The figures of *Syzygophyllum brevis* are by no means unlike many specimens of *Rhizangia elongata*, and the description given by Ruess supplies some particulars which are equally consistent with it. The broadly-attached corallum, the moderately-developed columella with its papillated upper surface, the anastomozing septa, and the toothed mural costæ (when not obscured by epitheca) sufficiently illustrate this. The lateral ornamentation of the septa, and the endotheca, appear, however, to differ materially. The following is a translation of the words used by Ruess:—"The lateral surfaces of the septa are united by numerous thin, very flat, bow-shaped, endothecal lamellæ, which form a large vesicular mesh-work. Together with them they bear scattered granular pimples. In a cross-section of the corallum the endothecal vesicles are observed forming pretty regular concentric rows." I may call attention to the ornamentation of the septa shown in the magnified figure (Fig. 8*b*), and suggest that the genus *Syzygophyllum* is one which demands further investigation.

Although I have myself collected corals from the cliff at Hunstanton, I am unable to speak of their precise position in it. That deficiency has, however, been fully made up by Professor T. Wiltshire, who has taken *Rhizangia mamilliformis* from the top to the bottom of the Red Chalk, and *Rhizangia elongata* from the middle part only.[1]

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[1] Foss. Korall d. Österreichisch-Ungarischen Miocans, Taf. vi. fig. 1.

[2] Foss. Korall des Österreichisch-Ungarischen Miocans, p. 36. Taf. v. figs. 6–9.

There is great reason for supposing that the genus *Rhizangia* occurs in the Oolitic strata of Gloucestershire. I have seen two corallites attached to a *Thamnastræa* from the Lower Trigonia grit of Ravensgate Hill, Cheltenham, which are probably referable to that genus; and I have one from a bed of Oolitic gravel between Cirencester and South Cerney. The latter is without doubt a *Rhizangia*, and as it was associated with other Oolitic corals, it was probably derived from some part of the Oolitic series.

RHIZANGIA MAMILLIFORMIS, Dunc. sp. Pl. XIV. Figs. 7, 8, and 9.

Podoseris mammiliformis, Duncan. Supp. Brit. Foss. Cor. pt. ii. p. 25, pl. ix. figs. 2-15, 1868.

The greater number of the specimens from Hunstanton consist of isolated and worn corallites. A limited number show the base and its ragged margin, while in three instances only have I seen the corallites connected by the calcified stolon. Not unfrequently specimens may be observed attached to Belemnites, over which the thread-like extension of the stolon is seen. A short piece of a Belemnite now before me is so completely enclosed, as to have led in the first place to the supposition that it was wholly coralline, until by an accidental fracture the unmistakeable structure of the Belemnite was revealed.

RHIZANGIA ELONGATA, Dunc. sp. Pl. XIV. Figs. 10 and 11.

Podoseris elongata, Duncan. Supp. Brit. Foss. Cor. pt. ii. p. 26, pl. ix. fig. 16-17, 1868.

Although this species so much exceeds in height all others of the genus, I cannot detect any generic differences. Specifically *Rhizangia elongata* differs also from *R. mamilliformis* in having the dissepiments placed more on one level, that is, they collectively form masses which are more clearly defined and more nearly horizontal. In the latter species the layers of endotheca are more or less saucer-shaped, and when the convex calicular surface has been rubbed smooth and polished, they appear as rings, one within the other, having something the appearance of wall within wall.[2] In *Rhizangia elongata* these layers of dissepiments are seen when a vertical section of the corallum is made.

Genus LEPTOPHYLLIA, Reuss.

Turbinoseris, Duncan.

For a long time I have believed that the genera *Leptophyllia* and *Turbinoseris* were one and the same. Although I had not made such an intimate internal examination as would be necessary to determine their relationship on structural grounds, I found great difficulty in admitting as the representatives of distinct genera, forms which were so absolutely similar in all their more obvious characters. And this great general resemblance did not fail to strike other observers, fully competent to give an opinion.

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[1] See that gentleman's very interesting paper on the Red Chalk of Hunstanton, in the twenty-fifth volume of the Journal of the Geological Society.

[2] A horizontal section of a corallite, if only a little way below the calice, should correspond as nearly as is practicable with the surface of the calice, for otherwise some of the septa would be cut through much lower down than others. Indeed, the same septum would be reduced very unequally, and the endotheca more exposed in one place than another. As, however, there is no reason to suppose, *primâ facie*, that any important difference exists between the two sides of a *tall* corallum, a horizontal section taken low down seems unobjectionable.

Examples of *Leptophyllia clavata*, Reuss, from Gosau, and of *Turbinoseris de Fromenteli*, Duncan, from Atherfield, in my own collection, being placed before my late and much lamented friend Dr. Wright, brought forth the prompt affirmation of their generic identity. Of the generic peculiarities of *Leptophyllia*, M. E. Pratz has given so full an account, that it will be surperfluous for me to enter into the details.[1]

Although I have long been aware of the similarity in all outward details existing between *Leptophyllia clavata* and *Turbinoseris de Fromenteli*, I did not know that there were synapticulæ in the former. Now, however, that not only their presence but their precise conformation has been clearly demonstrated by M. Pratz, this is confirmation in my opinion of the unity of the genera *Leptophyllia* and *Turbinoseris*. The two genera thus brought together are, I know, placed by Prof. Duncan, the one, *Turbinoseris*, in the *Fungidæ*, and the other, *Leptophyllia*, in the newly-proposed family *Plesioporitidæ*; the supposition being that the former has imperforate, and the latter perforate septa. But I cannot see that the two differ generically from each other, and I therefore regard them as identical.

The earliest appearance of the genus is in the Oolite (assuming that the Oolitic *Leptophylliæ* structurally resemble those of the Chalk), and several species are recorded by Etallon and M. de Fromentel.

Of the upward range of the genus I can only decide from the evidence afforded by Reuss of the occurrence of a species in the older Tertiary strata of the Alps.[2] Not having had the opportunity of examining any of the West-Indian species of *Turbinoseris* described by Prof. Duncan, I am unable to speak of them, except to observe that I do not see anything in the description of either genus or species which is irreconcileable with that of *Leptophyllia*.

LEPTOPHYLLIA ANGLICA, Tomes.

Turbinoseris de Fromenteli, Dunc., Supp. Brit. Foss. Cor. pt. ii. p. 42, pl. xv. fig. 13—18, 1870.

As the genus *Turbinoseris* must give way to *Leptophyllia*, and a species has already been named after M. de Fromentel by M. Etallon, a new specific name is needed for the present species. I therefore propose that for the future the name *Anglica* be applied to it.

There are specimens in the British Museum which have been obtained from Potton, as well as others from Atherfield.

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[1] Palæontographica, vol. xxix. 1882.

[2] Paläont. stud. u. die Alter. Tertiärsch. der Alpen, p. 10, pl. xxxvii. fig. 1, and p. 36, pl. xliv. fig. 8.

Beaumontia Egertoni. Edw. and Haime, Monogr. Polyp. Foss. Terr. Palæoz. p. 276, 1857. Brit. Foss. Cor. pt. iii. p. 160, tab. xlv. fig. 1, 1852.

A large compound tabulate coral is sometimes met with in the coprolite beds of the Upper Greensand of Cambridge, which may be mentioned here, although there can be no doubt that it is a derived fossil, and from the Carboniferous Limestone. At present I know it only from the examination of a fragment struck off a mass of considerable size, and lent to me by my friend the Rev. P. B. Brodie. The internal structure has been well retained, and the nature of the tabulæ is very clearly observable. It is undoubtedly referable to the Favositoid genus *Beaumontia*, and the remblance to *Beaumontia Egertoni* is so great, that it may be unhesitatingly referred to it. Compared with other species of the genus, the present may be distinguished by the very slight degree of convexity of its tabulæ. It was described by MM. Milne Edwards and Haime from a specimen in the collection of the Geological Society, which was obtained by Sir P. Egerton from the Mountain Limestone of Sracrapagh, Ireland.

It is not without some interest to the geologist that the Cretaceous formation of this country is now found to have a greater resemblance in its Coral fauna to that of the Continent, than has been heretofore believed. Prof. Duncan has made known in his Supplement to the History of British Fossil Corals, and subsequently in the Quarterly Journal of the Geological Society, some genera and species of Corals from the Upper Greensand of Haldon and other localities, which indicate a nearer relationship between the English Coraliferous beds of the Cretaceous formation and those of the Continent than had been supposed. In the latter publication he concludes a paper on the Coral fauna of Haldon by the observation that it "appears to be the Northern expression of that of the French and Central-European deposits, which are the equivalents of the British Upper Greensand." The occurrence of such genera as *Ceratotrochus*, *Pleurosmilia*, *Barysmilia*, *Rhizangia* and *Leptophyllia*, now for the first time made known as occurring in the English Cretaceous beds, tends to approximate them still more closely with those of the Continent.

(The foregoing paper was read at the meeting of the Geological Society on the 24th of June, but was withdrawn by the author with the consent of the Council. It is now printed verbatim with figures by Mr. C. Berjeau of the specimens exhibited at that meeting.)

EXPLANATION OF PLATE XIV.

Fig. 1. *Smilotrochus calcaratus*. The corallum. Natural size.
,, 2. *Ib.* The corallum of another specimen. Natural size.
,, 3. *Ib.* The corallum of a young example. Natural size.
,, 4. *Ib.* The calice of No. 1. Much magnified.
,, 5. *Ib.* The spur of the same specimen. Much magnified, and showing the costæ.
,, 6. *Ceratotrochus insignis*. A vertical section of the corallum. Much magnified and showing the spongy columella.
,, 7. *Rhizangia mamilliformis*. Three corallites united by the stolon. Magnified.
,, 8. *Ib.* Two corallites similarly united. One of them being very little worn shows the denticulations of the septa. Magnified about half a diameter.

FIG. 9. *Ib.* Part of the polished calicular surface of a specimen showing the dissepiments in the loculi, to which reference is made at page 548, in the description of the genus *Rhizangia*.

„ 10. *Rhizangia elongata.* The synapticulæ as they appear in a vertical section. Highly magnified.

„ 11. *Ib.* A vertical section, showing the dissepiments arranged in irregular layers which are on nearly the same level in all the loculi. They are usually more fused together than is shown in the figure. Highly magnified.

„ 12. *Pleurosmilia Neocomiensis.* The corallum. Natural size.

„ 13. *Ib.* The calice. Natural size.

„ 14. *Barysmilia Cordieri.* A young example. Natural size.

„ 15. *Barysmilia tuberosa.* A young example. Natural size.

IV.—ON THE OCCURRENCE OF QUARTZITE BOULDERS IN A COAL-SEAM IN LEICESTERSHIRE.

By W. S. GRESLEY, F.G.S.

IN 1883 a scattered group of five boulders was met with in the workings of the Coleorton Colliery in the "Lount Nether" coal, at a depth from the surface of about 375 feet. They were all entirely enveloped in the coal, and occurred about 20 inches from the top of the seam. Four of them were found within a space of 20 yards of one another, but no two of them very near together, and the fifth occurred some 500 yards S.W. of the others. The coal-seam was of its normal thickness—namely, about 4½ feet. This is the seam marked "Lount 4" upon the Geol. Survey Sheet No. 46 of Horizontal Sections, and it is the lowest but one worked in the district.

The dimensions and weights of these boulders are:—

							lbs.	ozs.	
1.	7½	inches longest diam.	×	5¾	inches shortest	diam.	11	8	weight.
2.	7⅛	„	„	×	4½	„	„	5	4	„
3.	4¾	„	„	×	4⅛	„	„	2	10	„
4.	4¼	„	„	×	3	„	„	1	10	„
5.	2½	„	„	×	1¾	„	„	0	6¾	„

No two of them are at all alike in outward form, but all are considerably, or very much, rounded and smooth-surfaced. No. 1 exhibits, very markedly, the divisional planes due to original stratification; these run parallel to its flatter sides. The exterior is rather rough and here and there coated with scaly iron-pyrites and coaly matter, and a very little shale or clay adheres firmly to the boulder, and shows signs of considerable pressure. No. 2 is somewhat pear or wedge-shaped, but is well and smoothly worn all over. No. 3 highly rounded into a flattish circular mass, and very smooth all over. When broken through it exhibited a sharp, almost conchoidal fracture, and is evidently extremely compact. No. 4 has a large portion broken away on one side along an original joint (?); the edges are now smoothed and rounded off. No. 5 shows a rather singular convex surface, occupying about one-third of its area, which (to me) has the appearance of having been produced by some planing rather than rolling action, but there are no rough or clearly defined edges left; the striæ (if any really exist) are very minute. I certainly never remember seeing a quartzite pebble of a similar form.

All the stones seem to be composed of very similar rock, the colour outside being grey, blotched with black. The exterior for a depth of about ¼ inch, is of a darker shade than the interior of the stones; due no doubt to being so long in contact with the coal. I cannot detect any signs of fossils upon or within any of them.

From No. 2 a slide has been prepared, which I submitted to Prof. Bonney, and he has been kind enough to send me the following description of it:—"A very compact pale grey quartzite, consisting of rather angular fragments, often about ·01 inch diameter, of quartz, with which are a few more rounded grains of a decomposed kaolin-like material, which probably were once felspar; these have worn out of the slide in grinding. There are apparently a few specks of iron-oxide, but some of these may be mere accumulations in the above vacuities of the material used in grinding the slide. I note also a few flakes of colourless mica, a small grain or two of epidote, and one, partly broken away, which I think is tourmaline.[1] The rock macroscopically and microscopically is like some of the more compact quartzites in the pebbles of the Bunter in Staffordshire, and in the Loch Maree district; it differs in some respects from the quartzite of Hartshill, the Lickey, or the Wrekin. It reminds me of a quartzite pebble described by me some years since from the Coal-measures of South Staffordshire, of which, however, I do not possess a fragment for comparison. See GEOL. MAG. Vol. X. p. 289."

The seam of coal from which these boulders were taken is, at this colliery, particularly subject to "Horses" or "Wants," *i.e.* sudden interruptions in the continuity of the coal, its place being taken by sandstone and shale, exhibiting current-bedding, and often enclosing patches of detrital coal, &c. This coal-bed is here and there swelled up to double its ordinary thickness, and again, hard by, is reduced to half its proper thickness. It is also often mixed with layers or patches of sandstone, having a concretionary-looking formation, which set in and run out in a peculiar way.

The roof of the seam is very variable in composition: sometimes it is sandstone-rock, sometimes shale containing numerous strings and pipes of bright, glossy coal, and some clay-ironstone nodules. Again it is fire-clay or soft carbonaceous shale and coal mixed. [A roof richer in fossil plant remains I never witnessed in any colliery, and they are often exceedingly beautifully preserved. I have obtained specimens of the leaflets of ferns (the actual dead leaves themselves) and placed them between bits of glass to preserve them, which when exposed to a current of air, flapped up and down, though still fast by their stalks to the rock.] I mention all this to show that the conditions under which this Coal-seam and its roof were deposited were such as clearly indicate that currents of running water, having considerable weight and velocity, flowed at the time of, or immediately subsequent to, the formation of the Coal-seam; and as four out of five of these boulders were found within 80 or 90 yards from the edge of a "horse" or "wash-fault" of unusual width (100 yards), their connection with this interruption in the coal may be very close.

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[1] I have identified this mineral in a compact grey quartzite very like the above, which is among the Bunter pebbles, and find a grain of it in a slide cut from a similar quartzite which occurs on the Torridon road about three miles from Kinlochewe.—T. G. B.

Of the several theories advanced respecting the way in which boulders have become enveloped in Coal-beds, I am inclined to accept that one which supposes that they have been dropped or washed out of the roots of trees as they were floated along in flood-time from higher ground on which they grew. And there seems every reason to believe that as the matter composing the Midland Coal-measures undoubtedly came from the N.W., the parent rock from which these boulders have been derived existed more or less in that direction.

In conclusion it may be interesting to cite several other authenticated instances of the occurrence of quartzite or other boulders and pebbles, either embedded in seams of coal or in the "measures" enclosing them.

(*a*) In a colliery in *Shropshire*, a water-worn pebble of lead ore was taken (by Mr. George Spencer, the manager) from the top of a Coal-seam in the workings. [From this fact we learn that mineral veins—of lead-ore at any rate—were formed prior to the deposition of the Coal-measures.]

(*b*.) At Church Gresley Colliery, in *Derbyshire*, at 630 feet deep, in 1867 was found a boulder composed of hard, crystalline sandstone, dotted with small, angular quartz-pebbles, having a smooth, well-worn surface; it measures ten inches in diameter by six inches thick, and in this latter particular corresponded exactly with the thickness of the clay (the underclay of the "Little Coal" seam) in which it reposed. Again, quite recently (1885) four or five little grey quartzite pebbles, the largest being roughly the size of a hen's egg, were obtained from the same stratum of underclay in the same pit; they were all near together.

(*c*.) In *North Staffordshire* two instances of large rounded boulders occurring in the Coal-measures are mentioned in the Report (for 1865) of the British Association.—See "Reports," p. 42.

(*d*.) The *South Wales Coal-field* has yielded pebbles. See Memoir of Geological Survey, vol. i. p. 194.

(*e*.) In the *Forest of Dean Coal-field*. Mr. Buddle's account in Trans. Geol. Soc., 2nd series, vol. vi. p. 217.

(*f*.) The *Lancashire Coal-districts, including Cheshire*. Many boulders have been discovered in working the mines, accounts of which may be found in Memoirs of the Lit. and Phil. Soc. of Manchester, vol. ix. 2nd series, 1851; Trans. of the Manchester Geol. Soc. vol. xiii. p. 141; also vol. xiv. p. 373.

In *America*, in the *Tennessee and Ohio Coal-fields* quartzite boulders have occurred more or less buried in Coal-seams. See Dana's Manual of Geology, p. 317.

V.—PALÆONTOLOGY IN GERMANY AND AUSTRIA.

By Prof. ALBERT GAUDRY, Membre de l'Institut, For. Memb. Geol. Soc. Lond.

[NOTE BY THE TRANSLATOR.—M. Albert Gaudry, the well-known Professor of Palæontology at the Museum of Natural History of Paris, following up a report which he published last year of a visit to the British Museum (Natural History), Cromwell Road, has recently written an article in the "Revue Scientifique"[1] on a series of visits just paid to the Museums of Germany and elsewhere.

This article is valuable, not only for the statement of the existence of a great scientific movement on the Continent, but for the summarised sketch it gives of the most interesting geological and palæontological collections in the principal museums of Europe, a knowledge of which is often desiderated by the student when travelling abroad.—MARK STIRRUP.]

I SAW that Germany, like England, is erecting Museums of Palæontology; each counting it an honour to have a museum which displays the primitive history of its country.

Stuttgart possesses, besides its general museum in which are the products of different countries, a gallery of Geology and Palæontology, specially devoted to the fossils of Wurtemberg.

This local collection, directed by Professor Oscar Fraas, has a deserved reputation; for in it can be followed from age to age the palæontological history of one of the best studied countries of Europe.

It is there especially that the astonishing reptiles are seen which lived upon the continents at the epoch of the Trias; the *Atosaurus*, the *Zanglodon*, the *Mastodonsaurus*, the *Metopias*, etc., permit one to form some idea of the strange aspect of the fauna of this epoch.

The museum of Stuttgart is also one of those in which the Liassic epoch is well represented; it possesses the Holzmaden collection, celebrated for its entire skeletons of reptiles.

M. Fraas had the kindness to take me to this locality some years ago, in order to show me in what condition the fossils are found; most frequently they are encrusted with stone, and only swellings or protuberances are seen, which would teach nothing to an uneducated eye; but M. Fraas is able to foretell where the head, the members, the tail, are to be found, and even he could tell me what kind of animal must be there concealed. It is by the graving tool that those entire skeletons are developed which are the ornament of a great number of museums, and of which we have in Paris some magnificent specimens.

The collection of Stuttgart contains many *Ichthyosauri* with young ones enclosed within their ribs, generally they (the young) have the head turned towards the anus, as in other viviparous animals; nevertheless I have seen one which has in its interior two young ones turned towards the head, and another which has six little ones *in ventre* turned in every direction. Must one suppose that the *Ichthyosaurus* had sometimes a single young one, like the terrestrial

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[1] *Extract* "REVUE SCIENTIFIQUE," 7 Nov. 1885.

Salamander, sometimes several young ones as the viper or the blind worm? This appears to me extraordinary, and explains why it was formerly believed that the young found in the interior of the *Ichthyosaurus* had been eaten by it.

Munich possesses important collections of palæontology administered by Professor Zittel: for example, that of Ammonites which, it is said, is the most complete in existence, and the series of admirable preparations of fossil sponges, whose skeletons Dr. Zittel has developed by steeping in acidulated water.

I have seen again with pleasure the fossils of Pikermi, that Wagner had the merit of first making known.

But the principal curiosity of the Palæontological Museum of Munich is the collection of fossils of the Lithographic Stone or Upper White Jura, of Solenhofen, in Bavaria.

If one must go to Stuttgart to study the Trias and Lias, it is to Munich one must proceed to admire the Oolite.

All geologists know that the stones of Solenhofen were originally mud, which was deposited upon a shore, where at the same time the inhabitants of the sea met those of land; in this mud, creatures of the most different and the most delicate organization, belonging to the Oolitic epoch, are preserved in the most astonishing perfection; one finds there, down to Acalephæ, a multitude of Crustacea, insects which have retained the most delicate neuration of their wings, their legs and antennæ; Ammonites with their aptychus, and Fishes which are in course of passing from the Ganoid to the Teleostean state. It is there especially that one goes to study the flying reptiles, where they appear in all positions.

There also may be seen the little *Compsognathus*, which long before the discovery of the entire Iguanodons of Belgium enabled us to understand the appearance of these Dinosaurians. The palæontologist thinks he is dreaming whilst contemplating this gathering together of beings which permit him to fancy himself in the Secondary period almost as perfectly as if it were the present epoch; one can readily believe, after seeing this grand collection, that a day will come, in which our successors will have a clear idea of the life-history of all past ages.

It is well known that Vienna, for a long time deservedly extolled for its animation and gaiety, is becoming a splendid city, that its fortifications have been replaced by spacious boulevards bordered by gardens, fine houses and palaces.

Science is about to profit largely by these transformations.

On one side of the new Hotel de Ville, the sumptuous palace of Parliament has been erected, and as a companion building on the other side, the palace of the University.

At a short distance from the Palace of Parliament, opposite the Palace of the Emperor, they are finishing, at this moment, the Museum of Fine Arts and the Museum of Natural History. Thus the University and the Museum of Natural History are in the most magnificent quarters of Vienna; it is not as in Paris, where our Jardin des Plantes is banished so far from the centre.

The building of the University is nearly finished; it is a pleasure to be a student in such a palace; marble has been lavished upon it; it is reached by a vast flight of steps. An eminent savant, Professor Suess, a Member of Parliament, directs the collections of geology, and another professor equally able, M. Neumayr, superintends those of palæontology.

The Museum of Natural History (Hof Naturalien Museum) belongs to the Crown. The Emperor has just placed at its head Dr. Franz Ritter von Hauer, who was formerly Director of the Geological Institute. M. Fuchs is specially charged with the department of palæontology. The buildings are advancing rapidly, and a large part of the collections are expected to be arranged before the coming spring. I was told that the fossils will be, as in the old museum, separated from the representatives of living creatures, and that they will occupy six rooms. The vertebrate room is ornamented with mural paintings, which represent landscapes of the world at different geological epochs with the most characteristic animals and plants. These paintings are separated from one another by statues which have their palæontological attributes; one holds an *Ichthyosaurus*, another a head of *Dinotherium*, another a piece of *Cervus megaceros*, another a head of *Uintatherium*, etc. I have seen few fossils, because all is in process of removal. Among those which M. Fuchs was able to show me, I observed some skeletons of *Ursus spelæus*, a skeleton of *Megaceros*, another of the Quaternary Ibex, some fine specimens of *Mastodon*, of *Dinotherium* and a series of vertebrates from Maragha, in Persia, of the same age as those of Pikermi and those of Baltavar in Hungary, described by M. Suess.

Besides the collections that I have just cited, there is the Geologische Reichanstalt, which the new Director, Herr Dionys Stur, had the kindness to show me. The fossils are there arranged according to their geographical and geological order; it is perhaps the finest collection of stratigraphical palæontology which exists in Europe. One admires especially the series of Ammonites from the Trias of the Austrian Alps, upon which M. de Mojsisovics has lately written some most important memoirs.

I have not been recently to Pesth; but two learned Hungarian professors, M. de Hantken and M. Szabo, have assured me, that since I was in that city, its collections of geology and palæontology have become very important.

At Prague, Professor Fritsch conducted me over the site where the foundations have just been laid of a large museum of science for Bohemia; pending the erection of the new building, they have built near the old museum of Bohemia a provisional hall specially consecrated to palæontology. Professor Fritsch has there arranged numerous and very remarkable fossils classed age by age. The immense collection of Silurian fossils which was made by Barrande, and given by him to Bohemia, has been left in the apartment which our illustrious and revered compatriot occupied in the Chotek Gasse. It is difficult to imagine the immense number of *Orthoceratites*, *Cyrtoceratites*, *Trilobitæ*, etc., in this apartment. I had there a proof of the degree to which the love of palæontology can reach, for in the rooms, more than simple, in which the old tutor of the Comte de Chambord passed the greatest part of his life, there are collections of Primary fossils which have cost enormous sums.

Barrande was parsimonious with regard to himself, prodigal for science. His collection will be removed into the museum which is now being built. A young Czech professor, M. O. Novák, and a German savant, M. Waagen, well known for his work upon the palæontolgy of India, are engaged in continuing the gigantic labours of Barrande upon the Silurian fossils of Bohemia.

Dresden, whose picture galleries draw artists from all countries of the world, has also accorded a large development to its galleries of geology and palæontology. They are in the same palace (Zwinger) as the objects of art. The Director, Prof. H. B. Geinitz, has arranged the fossils by geological ages, in a way that one can readily form an idea of the life-history of past times. The creatures of the Permian epoch are particularly well represented there; no one has contributed so much as Prof. Geinitz in making known this epoch, which was formerly believed to have represented a momentary suspension in the vital forces, but which, on the contrary, has furnished for some years past a multitude of fossil plants and animals.

Berlin has quite another character to Vienna: while the latter aspires more to pleasure, Berlin prefers the harshness of a military life. Nevertheless its government, which above all neglects nothing which relates to war, occupies itself also with science, for it knows that Knowledge is Power.

A vast building has just been constructed in Invaliden Strasse for the geological collections directed by M. Hauchcorne, and another for the collections of the agricultural arts, where M. Nehring has assembled the curious Quaternary fauna, which he has described under the name of the Fauna of the Steppes; between these museums, a large Museum of Natural History is about to be erected.

The University has some fine collections of geology directed by Professor Beyrich, and of palæontology superintended by Professor Dames; it is at the University that the second specimen of *Archæopteryx* may be seen, for which £1000 was paid. It has the advantage over the British Museum specimen, of having its head, and of showing its fore limbs, whose metacarpal bones are not anchylosed immovably together as in existing birds, but are free and furnished with clawed digits.

(Herr Dames has published a most interesting memoir on this specimen, a notice of which appeared in the GEOLOGICAL MAGAZINE, 1884, Decade III. Vol. I. pp. 418–424, Pl. XIV.)

VI.—"CONE-IN-CONE."[1]

By Prof. J. S. NEWBERRY, M.D., For. Memb. Geol. Soc. Lond.;
Professor of Geology in Columbia College, New York.

IN the June Number of the GEOLOGICAL MAGAZINE an abstract is given of a paper on Cone-in-cone, read by Mr. John Young before the Geological Society of Glasgow, in which he advances the theory that this peculiar structure is caused by the escape of gases.

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[1] The MS. of this article was unfortunately mislaid, and its publication consequently delayed some months, for which the Editor begs to apologise.

While I was yet a boy I found cone-in-cone, and was puzzled by it, but examining a fine exposure of it in which the bases of the cones were all turned upward, the theory of escaping gases suggested itself to me. Subsequently, when I was a student in the Jardin des Plantes, Paris, attending the geological lectures of M. Cordier, he described cone-in-cone as an imperfect crystallization. I proposed to him the theory of the escape of gases through a pasty medium, but he said that would not do, because the points of the cones were sometimes turned upward, sometimes downward. This led me to review the subject later, and while I had the supervision of the Geological Survey of Ohio, and was connected with the Government Surveys in the Western Territories, I had opportunities of observing the occurrence of cone-in-cone in a large number of localities, and at many geological levels. The results of my observations are given in the Report of the Geological Survey of Ohio, Vol. I. p. 211. They are briefly as follows:

Cone-in-cone consists, as is well known, of a series of hollow cones like extinguishers placed one within another, and it sometimes makes up the entire mass of a stratum several inches in thickness and many feet in lateral extent. It is not confined to one horizon, but occurs throughout the geological series wherever there are argillaceous shales, locally impregnated with lime, or in which septaria or clay-iron-stones are found. More generally the cone-in-cone structure is observable in lenticular sheets of earthy limestone or shale impregnated with lime, and in each sheet the cones are usually turned in the same direction, oftenest with the points down, but sometimes turned upward, and occasionally turned in both directions. In one locality in Ohio where cone-in-cone occurs abundantly in the Waverley shales (Lower Carboniferous), a lenticular mass is divided obliquely by a sheet of clay-iron-stone. On one side of this the points are turned downward, on the other side they occupy a reversed position. I have before me as I write a nodule of iron ore from the same locality which is surrounded by cone-in-cone two inches in thickness; the cones above are turned point downward, those below point upward, and those on the sides, somewhat confused by pressure, are divergent.

In the Cretaceous formation of Colorado lime concretions occur with a radiated cone-in-cone structure, and similar concretions are reported by Dr. C. A. White in the Coal-measures of Iowa (Amer. Journ. Science, vol. xlv. 1868, p. 401). Again, in the Huron Shale (Upper Devonian) of Ohio, the bones of the great fishes (*Dinichthys*) are generally coated with a sheet of impure limestone which has cone-in-cone structure; and here the cones are divergent from the surfaces of the bones, however irregular these may be.

Such specimens as these I have described seem to me to be incompatible with the theory that cone-in-cone is caused by pressure or the escape of gases, and appear rather to confirm the conclusion that it is due to an impeded tendency to crystallization.

NOTICES OF MEMOIRS.

BRITISH ASSOCIATION: ABERDEEN.

PAPERS READ BEFORE SECTION C. GEOLOGY.

I.—ON SLATY CLEAVAGE AND ALLIED ROCK-STRUCTURES; WITH SPECIAL REFERENCE TO THE MECHANICAL THEORIES OF THEIR ORIGIN. By ALFRED HARKER, M.A., F.G.S.

SINCE Professor Phillips' Report to this Association in 1856, the subject of Cleavage, especially in connection with Foliation, has received much attention. In the present communication the mechanical theories of Mr. Sharpe and Dr. Sorby are discussed at length, and pursued through their various consequences, such as the variation of Cleavage in rocks of different natures and the peculiarities of Cleavage-planes which traverse alternating strata. A section is devoted to the mode of working slate-rock in the quarries, which throws much light on the structure of the rock. The spurious and incipient Cleavages due to minute contortion or faulting of the rocks are next described. A consideration of the general effects, mechanical, physical, and chemical, of pressure upon rocks leads to a discussion of the relations between Cleavage and Foliation, and the extent to which the latter can in many cases be referred to the action of mechanical forces. The concluding section deals briefly with the relation of Cleavage to Earth movements.

II.—ON DEEP BORINGS AT CHATHAM. A CONTRIBUTION TO THE DEEP-SEATED GEOLOGY OF THE LONDON BASIN.

By W. WHITAKER, B.A., F.G.S., Assoc.Inst.C.E.

A FEW years ago the Admiralty made a boring in the Chatham Dockyard extension, to the depth of 903½ feet, just reaching the Lower Greensand, and in 1883-4 followed this by another boring, near by, to increase the supply, which has led to an unexpected result. After passing through 27 feet of Alluvium and Tertiary beds, 682 of Chalk, and 193 of Gault, the Lower Greensand was again reached; but, on continuing the boring, was found to be only 41 feet thick, when it was succeeded by a stiff clay, which, from its fossils, is found to be Oxford Clay, a formation not before known to occur in Kent.

At its outcrop, about seven miles to the south, the Lower Greensand is 200 feet thick, and is succeeded, a little further south, by the Weald Clay, there 600 feet thick. Not only, however, has this 600 feet of clay wholly disappeared, but also the whole of the next underlying set of deposits, the Hastings Beds, which crop out everywhere from beneath the Weald Clay, and are also some hundreds of feet thick.

More than this, the Purbeck Beds, which underlie the Hastings Beds near Battle, are absent, and also the Portlandian, Kimmeridge

Clay, Corallian, etc., beds which have been proved above Oxford Clay in the Subwealden Boring, to the great thickness of over 1600 feet.

We are therefore faced with a great northerly thinning of the beds below the Gault, a fact agreeing in the main with the evidence given of late years by various deep wells in and near London.

Three other deep borings have been made or are being made near Chatham, all of which have passed through the Chalk into the Gault, and one has gained a supply from the sand beneath.

The practical bearing of the Chatham section is, however, to enforce the danger of counting on getting large supplies of water in the London Basin from the Lower Greensand, by means of deep borings at any great distance from its outcrop.

Even if Lower Greensand occur at all in such places, it will probably be in reduced thickness, and therefore with reduced water-capacity.

III.—ON THE RE-DISCOVERY OF LOST NUMIDIAN MARBLES IN ALGERIA AND TUNIS.

By Lieut.-Colonel R. L. PLAYFAIR, H.M. Consul-General for Algeria and Tunis.

THE author explained that the name itself was a misnomer, as they are not found within the limits of Numidia proper, but in the province of Africa and in Mauritania. Most of the 'Giallo antico' used in Rome was obtained from *Simittu Colonia*, the modern Chemton, in the valley of the Medgérda, the quarries of which are now being extensively worked by a Belgian company; but the most remarkable and valuable marbles are found near Kleber, in the province of Oran, in Algeria. There, on the top of the Montagne Grise, exists an elevated plateau, 1500 acres in extent, forming an uninterrupted mass of the most splendid marbles and breccias which the world contains. Their variety is as extraordinary as their beauty. There is creamy white, like ivory; rose colour, like coral; Giallo antico; some are as variegated as a peacock's plumage; and on the west side of the mountain, where there has been a great earth-movement, the rock has been broken up and re-cemented together, forming a variety of breccias of the most extraordinary richness and beauty.

Colonel Playfair exhibited specimens of the principal varieties, to prove that his descriptions were not exaggerated. The beauty of these marbles has been recognised by the Trustees of the British Museum, who are now mounting the sculptures of the Parthenon and the Mausoleum on basements of them. Specimens may also be seen in the Mineralogical Room of the British Museum, at South Kensington.

The marble mountain belongs to Signor del Monte, of Oran, and, although it is not being worked as it ought to be, blocks can be obtained at a cost of about £18 per cubic mètre, ready for shipment.

REVIEWS.

Manual of Geology, Theoretical and Practical. By John Phillips, LL.D., F.R.S.—Part II. Stratigraphical Geology and Palæontology. Edited by Robert Etheridge, F.R.S., Assistant-Keeper, Geological Department, British Museum. pp. 712, with 33 plates, 116 tables of organic remains, and full index. (London: Charles Griffin & Co., 1885.)

LAST year the first instalment of the new edition of "Phillips's Manual of Geology," by Prof. Seeley, was reviewed in the Geol. Mag. We have now to welcome the companion volume from the pen of Mr. Robert Etheridge, for many years Palæontologist to the Geological Survey, and quite recently President of the Geological Society of London. Owing to the great amount of matter contained in this work, the publication has been somewhat delayed, and students of geology have been anxiously waiting for the appearance of the long-promised volume. It is only right to remark that, although bearing the name of Phillips, Part II. contains very little of the original text—less indeed than the part edited by Prof. Seeley. This circumstance arises from the nature of the subject, and from the great advances which have been made in stratigraphical geology, both at home and abroad, no less than in palæontology, during the last 30 years. The original illustrations of organic remains have been culled and added to, and these now form a series of 33 plates, which contribute much to the instructive character of the work before us.

The publishers have been fortunate in securing the services of Mr. Etheridge for this great task, requiring qualifications which he probably possesses to a greater degree than any of his contemporaries. He has had immense experience as Palæontologist to the Survey, whose valuable collections it was his duty to sift and in part arrange during the many years he was at Jermyn Street. His two addresses from the Chair of the Geological Society afforded also an intimation of the great stores of knowledge which he had accumulated. Moreover, his well-known industry and peculiar aptitude for arranging facts in a tabular form eminently fitted him for the work he has undertaken. The records of geological literature are becoming so vast that it requires an almost gigantic industry to deal with them. Hence the size of publications, nowadays, is almost more portentous than their number, and in this case it has evidently been a difficult matter to condense the subject within the limits of a single volume.

A bird's eye view of the geology of the British Isles in the shape of a small map constitutes the frontispiece. The general result is sufficiently accurate considering the smallness of the scale, but in one or two cases (Cornwall for instance) the colours denoting Granite and Basalt respectively have got transposed. The author still depicts the great mass of the Scotch Highlands as Lower Silurian; and indeed who shall gainsay him in the present state of the controversy?

If the so-called Upper Gneiss is to be regarded as the result of the rolling out of Archæan rocks in Palæozoic times, with the production of abundant crystalline change, and in some cases even with an incorporation of Palæozoic strata, it becomes almost a point of casuistry to what period these great mountain masses should be assigned.

In the earliest chapters the author devotes a few pages to the beginning of things, though of actual Cosmogony there is none. He still seems to regard "Eozoon" as a gigantic Foraminifer, which flourished in the earlier seas under a temperature a little below boiling point. After comparatively brief allusions to Archæan topics, he fairly settles down to his work (Chapter IV.), and with the help of Dr. Hicks gives us the base of the Palæozoic column as it appears in England.

Part I. of this volume, with the exception of the introductory matter previously noted, is devoted to the LOWER PALÆOZOIC ROCKS (Chapters IV.—XVII. inclusive), and may be regarded as containing a most exhaustive summary of the several faunas hitherto discovered in the British area. It might perhaps be going too far to say that the arrangement in all cases is not open to criticism. The author seems to have had such a press of matter, that he has been somewhat puzzled where and how to place it, and his difficulty has been further increased by the conflicting nomenclature of the system itself and its primary divisions.

The Harlech or Longmynds, the Menevians, the Lingula Flags, and the Tremadoc rocks constitute the first or lowest section. This section corresponds to a certain extent with the first or primordial fauna of Barrande. Most of the great groups of Invertebrates here enter an appearance for the first time. This fauna is rich in Trilobites, especially of the genera *Agnostus*, *Paradoxides*, *Niobe*, etc. As an example of the author's method of handling a particular series we append an abridgment of the "Palæontology of the Lower Tremadoc Rocks" (p. 54) :—

"HYDROZOA.—The Shineton Tremadoc rocks have yielded two species, *Clonograptus* and *Bryograptus Callavei*, of Lapworth, both belonging to the family Dichograptidæ. These are the *oldest Rhabdophora known.*

"ACTINOZOA.—None known below the Llandeilo rocks.

"ECHINODERMATA.—*Dendrocrinus cambrensis*, Hicks, and *Palæasterina Ramseyensis*, Hicks, are both from the Lower Tremadoc beds of Ramsey Island, St. Davids ; they *are the first known species* of the orders Crinoidea and Asteroidea.

"CRUSTACEA.—Only two new genera appear with the coming-in of the Lower Tremadoc . . . ; but the whole Crustacean fauna comprises 13 genera and 24 species, of which 10 genera and 19 species especially characterize the Lower Tremadoc. They are so essential to a right understanding of the Lower Tremadoc rocks, and so distinct from the fossils of the Upper Lingula Flags, that we enumerate them. . . . . The Lower and Upper Tremadoc are connected only by *Agnostus princeps*, *Ampyx prænuntius*, and *Ogygia scutatrix.*

"POLYZOA.—*Dictyonema sociale* as in the Upper Lingula Flags, also near Tremadoc in the passage-beds.

"BRACHIOPODA.—The Lower Tremadoc Brachiopoda are . . . . Four of these genera and 6 of the 11 species pass to the Upper Tremadoc. . . . .

"PELECYPODA (LAMELLIBRANCHIATA).—The Tremadoc rocks of Ramsey Island have yielded the first evidence of Pelecypod or bivalve molluscan life in Britain. They are referable to 5 genera and 12 species — *Davidia* (2), *Glyptarca* (2), *Modiolopsis* (4), *Palæarca* (2), and *Ctenodonta* (2); none of the species are known out of . . . . the Lower Tremadoc.

"GASTEROPODA.—None known below the Arenig rocks.

"PTEROPODA.—The genus *Theca* is represented by five species in the Lower Tremadoc. . . . . The three first named pass to the Upper Tremadoc. . . . .

"HETEROPODA.—*Bellerophon ramsayensis* and *B. solvensis* characterize the Tremanhire or Solva and Ramsay Island beds.

"CEPHALOPODA. None below the Upper Tremadoc."

Referring to the Hydrozoa, there appears to be a slight slip on p. 58, where the author says, "No Rhabdophora are known below the Arenig rocks," and also at p. 59, where he says, "No Rhabdophora occur below this line anywhere." It is true that in both these cases he is alluding to Wales, but it would have been safer to have made a reservation. Again, in the general table, page 141, he quotes *Diplograptus pristis* and *D. folium* as occurring in "Tremadoc Slates."

The second section of the Lower Palæozoic rocks comprises the Arenig or Skiddaw series; the Lower Bala and Llandeilo Flags; the Caradoc Sandstone, Bala Beds and Coniston Limestone; and lastly the Lower Llandovery rocks. This grouping corresponds in the main with the second fauna of Barrande, and comprises the principal portion of the Lower Silurian of the Geological Survey. The author has largely availed himself of the discoveries of Harkness, Nicholson, Hicks, Lapworth and Callaway, whose labours, since the first appearance of Phillips's Manual, have shed such a flood of light on the palæontology of these at that time little known rocks. It is quite within the memory of many of us that the Skiddaw rocks were supposed to contain hardly any fossils: yet here we find 70 species enumerated, mostly Graptolites. There may be some numerical error here, however; for at p. 63 he says that 28 species of Rhabdophora occur in the Skiddaw Group, whilst in Table VIII. p. 66, there are 48 species of Hydrozoa enumerated from Skiddaw, which is in Cumberland, and not in Westmoreland, as the author supposes. In the corresponding Arenigs of South Wales, out of 88 species enumerated, the Hydrozoa and Crustacea are about equally represented.

Certain authorities object to the per-centage system, which is no doubt somewhat inelastic, and was perhaps more calculated to command attention in the days when people attached greater importance to "species" than is now the case. We know for instance that Mr. Marr demurs to the system as one which in the present state of synonymy and incomplete determination of forms is premature, if not altogether objectionable. Nevertheless it is a rough and ready sort of way of separating the several series, and certainly it is impossible not to admit the distinctness of such a fauna as the Arenig for instance, ushered in by an influx of Graptolites, and terminated, Mr. Etheridge tells us, by a change of genera and species which has scarcely any parallel in the Palæozoic rocks.

That this should be the case in the Lake District is not to be wondered at, since some of the thickest volcanic accumulations known in these islands are superimposed; and the author hints (p. 68) that the Borrowdale series may, in Wales, be represented by the Aran and the Arenig volcanic beds, the Llandeilo slates, and the Snowdon volcanic series. Subsequently (p. 80) he throws doubts on the Llandeilo age of the Borrowdale rocks "from the fact that the great series of Llandeilo rocks in the south-west of Scotland appears to be free from intermixture with contemporaneous igneous matter."

The Llandeilo age of the Lower Moffat Shales is determined through the total absence of those complex Arenig forms of *Dichograpti*, *Tetragrapti* and *Phyllograpti*, so characteristic a feature of the Graptolithic fauna of the Skiddaw, Shelve, and St. Davids beds, together with their Canadian equivalents. It is through the Hydrozoa, Crustacea, and Brachiopoda chiefly that the Llandeilo rocks are connected with the overlying Bala or Caradoc; 77 species out of 175 passing from the former to the latter. The Sedgwickian, we know, would do away with the Llandeilo altogether as a geological series, and Mr. Etheridge considers that the large community of species is confirmatory of the views of Sedgwick: yet in spite of this he gives great prominence throughout to the "Llandeilo Series." On the other hand, no more than 102 species out of 610 pass from the Caradoc to the Lower Llandovery, which, together with the Upper Llandovery, he suggests might be classed as passage-beds under the title of Middle Silurian. Under this arrangement the Wenlock and Ludlow series would constitute the fourth and final section of the Lower Palæozoic rocks.

It is hardly necessary to remark that in all cases the foreign equivalents of each group or series are discussed at some length; and if the reader requires further information, he has only to consult the works to which reference is made. Meantime he is reminded of the immense amount of research which has been effected of late years in the Lower Palæozoic areas both of Europe and America.

On pp. 139–141 is given a "Tabular view of the Cambrian and Silurian strata, with Physical and Palæontological particulars." In this table the Menevian series is altogether omitted, or else absorbed in the Lingula Flags. On pp. 142–149, Table XVI. the author enumerates the "Organic remains of the Lower Palæozoic Strata": the genera are arranged alphabetically, whilst the number of species is brought down to date. Finally, on p. 150, Table XVII. shows the numerical history of the "Lower Palæozoic Series."

We have noticed at some length the author's treatment of the Lower Palæozoic rocks, both because he is known to be especially well acquainted with their palæontology, and also as affording an example of his mode of treatment of the several systems which succeed. The remaining notices must be brief.

Three chapters are devoted to the "Middle Palæozoic Strata," comprising the Devonian and Old Red Sandstone. The author gives us the views of Prof. Geikie on the several lakes or basins in which the Old Red Sandstone of Britain was deposited: also a very detailed description of the Devonian rocks, their correlation and fauna. "Perhaps during no period in the physical history of the British Islands has such an assemblage of Actinozoa occurred as that which specifically characterizes the Middle Devonian rocks of South and North Devon, as well as the Rhenish provinces, Scandinavia, and North America" (p. 200). "With the exception of the fishes of the Old Red Sandstone (120 species), the Brachiopoda is the largest group of the British Devonian rocks. We should expect this when we know that no less than 61 genera and over 1100 foreign described species have passed through the hands of European, American, and British palæontologists. Of these 1100 species only 114 are British" (p. 202). We have reason to rejoice in the reflection that our native palæontologists have been comparatively merciful.

Six chapters are devoted to the "Upper Palæozoic Strata," or in other words to the Carboniferous system, which in England, according to the author, when fully expanded, admits of division into the following six groups, not, however, to be found together in every district.

Coal Measures	Upper Group.
Millstone Grit	
Yoredale Rocks	Lower Group.
Scar Limestone	
Lower Limestone Shales	
Calciferous Sandstone	

Subsequently this is replaced by a quaternary grouping.

The author devotes a chapter to general considerations of the Carboniferous system, and we find at p. 225 the remarkable statement that the Upper or true Coal Measures were chiefly, if not entirely, "terrestrial or land formations." Surely these extensive accumulations, in places 12,000 feet thick, were laid down in water, though such water may have been fresh or brackish for the most part; even if the Coal itself, which forms but a fraction of the Coal-measures, happened to have been formed on a land surface. In connection with the Coal areas of England, he makes the following statement (p. 226), "These Coal-fields are separated at the surface by the overlying New Red Sandstone. . . . . They are, however, connected underneath." Surely this is not so in all cases, since the three great Coal areas of Durham, Lancashire, and South Yorkshire are separated at the surface by *lower* beds, and cannot therefore possibly be connected underneath, although they may have once formed parts of a continuous basin of deposit.

Chapters on the Carboniferous strata of Scotland and Ireland, on the Coal-fields of the Continents of Europe and America, and General Considerations relative to the history of Coal serve to show how extensively Mr. Etheridge has dealt with this most important subject before attacking the palæontology in detail.

According to the census given on p. 276, the PLANTÆ of the British Carboniferous rocks number 75 genera and 328 species, their stratigraphical distribution through the following eight series or groups of strata being as follows:—

Calciferous Sandstone...	10 genera and	12 species.
Lower Limestone Shale	22 ,,	44 ,,
Carboniferous Limestone	13 ,,	22 ,,
Yoredale Rocks	none.	none.
Millstone Grit	10 ,,	27 ,,
Lower Coal-measures...	54 ,,	211 ,,
Middle...	34 ,,	128 ,,
Upper	33 ,,	168 ,,

Ten genera are largely represented in Britain, and contain 192 species out of the known 328; they are *Alethopteris* 10 species, *Asterophyllites* 12, *Calamites* 12, *Lepidodendron* 22, *Lepidostrobus* 8 (probably we may never know to what species of *Lepidodendra* all these *Lepidostrobi* belong), *Neuropteris* 23, *Pecopteris* 29, *Sigillaria* 31, *Sphenopteris* 34, *Ulodendron* 11.

With regard to the ACTINOZOA, he says that 9 families, 39 genera, and 145 species constitute the Carboniferous Cœlenterate fauna, the most prolific families being the Favositidæ and Cyathophyllidæ. No species of Coral is known above the Yoredale rocks, and only 2 species occur in that series, viz. *Favosites tumidus* and *Zaphrentis Phillipsii.* The Carboniferous Limestone contains nearly all the species in the list, and evidence may be obtained of extensive reefs composed mainly of *Lithostrotion*, *Lonsdaleia*, and forms of *Cyathophyllum.* Of the Carboniferous POLYZOA he further says that "as a group (they) constitute by far the largest series in any division of the Palæozoic rocks." Seventy-eight species range through the three lower horizons, *i.e.* through the Carboniferous Limestone, the Lower Limestone Shales, and the Calciferous Sandstone, the whole group essentially belonging to the calcareous rocks and shales. *Ceriopora*, *Fenestella*, *Glauconome*, and *Polypora* are the most prolific genera. The author is not quite correct in stating that not a single species of Polyzoa occurs in the Millstone Grit; since a species of *Fenestella* is by no means uncommon in the "Cayton Gill Beds," though possibly it may not have been named as yet. Nevertheless we rather think that it is quoted in one of Mr. Fox Strangway's Geological Survey Memoirs. Moreover we believe that where the limestones are thick in the Yoredale rocks, possibly more than two species of Corals might be obtained.

Two chapters are devoted to the "Permian or Dyas Strata," which the author regards as probably of *freshwater* origin. From a paragraph on page 307 we arrive at this interpretation of *freshwater*:— "The water in these basins must have undergone extreme concentration, and chemical precipitation, so as to have resulted in the accumulation now presented of dolomites, saliferous clays, rock salt, gypsum, and anhydrite." Apart from this slip, we should demur to the statement that much of the Magnesian Limestone of the North of England was laid down in *freshwater* even of this peculiar kind, when we bear in mind the character of its fauna, pauperized it is true from Carboniferous types, but still unmistakably marine wherever fossils have been found. Referring once more to the conditions of deposition both of the Permian and the Trias, no one will quarrel with the author's subsequent statement that both these systems indicate a period of shallow seas and general disturbance resulting in the formation of land surfaces inclosing saline lakes, etc. "During this age many forms of life disappeared, and were replaced by others of a different type and order: hence, the Permian group is regarded as Palæozoic, and the Triassic as Mesozoic."

Somewhat less than one-half of the volume is occupied with the Palæozoic rocks, and of this portion we have endeavoured to give a brief and inadequate notice, showing more especially the methods adopted by the author, who continues to treat the remainder of his subject with equal fulness. Indeed, if there is any fault to find, it would be that too much matter is given, that the several paragraphs are not always in accord with each other, and that the work bears the impress of having been written at different times, producing rather a want of uniformity in some cases. But for the purposes for which it is required, more especially as a work of reference, this Manual possesses the highest value, despite such trifling and obvious slips as we have noted. We would especially direct attention to the Tabular Summaries, of which there are no less than 116 throughout the book. These present, in a most condensed form, an amount of information scarcely to be found in any other work. Undoubtedly it is a volume which must find a place in the library of every geologist who wishes to know what has been done in stratigraphical palæontology during the last thirty years. W. H. H.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

November 4, 1885.—Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On the Premaxillaries and Scalpriform Teeth of a large Extinct Wombat (*Phascolomys curvirostris*, Ow.)." By Sir Richard Owen, K.C.B., F.R.S., F.G.S.

The specimen described in this paper is a cast from a fossil discovered in a late exploration of the Wellington bone-caves, and sent to the author with some other casts from the same collection by the authorities of the Australian Museum, Sydney, New South Wales.

The fragments in question consist of the premaxillary bones, containing a pair of scalpriform incisors, 160 millim. (6½ inches) long, measured along the outer curve.

The teeth and the fragments of bone in which they are implanted were described in detail, and referred to the Wombat family. The animal to which they belonged must have been somewhat larger than *Phascolomys medius*, Owen, but less than the type of the sub genus *Phascolomys*. The specific name is suggested by the chief characters that distinguish the present form from any hitherto known, recent or distinct.

2. "On the Structure and Classificatory Position of some Madreporaria from the Secondary Strata of England and South Wales." By Prof. P. Martin Duncan, M.B., F.R.S., F.G.S.

This paper consisted chiefly of a criticism of the conclusions arrived at by Mr. R. F. Tomes in various papers communicated to the Society.

All the species of the genus *Astrocœnia* which were described in the Supplement to the British Fossil Corals, Pal. Soc. 1867, from the Infra-Lias of South Wales, belong to that genus, and not to *Stylastræa*, de From. The drawing of *Astrocœnia plana*, Dunc., given by Mr. Tomes, does not correspond with the type specimen of the species. *Stylastræa sinemuriensis* and *S. Martini*, de From., do not form part of the fauna of the Infra-Lias of South Wales. *Cyathocœnia*, Dunc., is not the same as *Phyllocœnia*, Laube, which is *Koilocœnia*, Dunc. *Thecosmilia Martini* and *T. Michelini* of the European Hettangian are found in the Infra-Lias of England. *T. rugosa*, Laube, was first noticed in the Memoir of the Corals of the zone of *Ammonites angulatus*, Pal. Soc. 1867, and the species was properly figured. *Cladophyllia* is a subgenus of *Thecosmilia*. *Elysastræa*, Laube, has two well-marked species in the Sutton Stone. *Montlivaltia simplex* has the shape of the calice not merely dependent on pressure, but caused by normal growth. *M. Walliæ*, Dunc., has no evidence of "rejuvenescence," and the growth noticed is endothecal, and would be termed by Lindström "stereoplasm." *M. polymorpha*, Terquem et Piette, remains a member of the Infra-Lias fauna. *M. pedunculata*, Dunc., is not a *Cladophyllia*, but a simple coral of the genus to which it was assigned by the author. The geological position of the Sutton Stone and associated deposits is, from the palæontological evidence, above the Rhætic series.

The cast of a *Montlivaltia*, figured by the author in the Memoir on the Corals of the Zone of *A. angulatus*, Pal. Soc. 1868, p. 68, does not coincide with *M. rhætica*, Tomes, but with *M. Haimei*. *M. foliacea*, Tomes, has not nine cycles of septa, as stated by its describer. The septal arrangement of *M. excavata*, Tomes, and *M. papyracea*, Tomes, is doubtful. *Thamnastræa* is not a perforate coral, but a Fungid. *Synastræa* and *Centrastræa* were not founded by M. de Fromentel: the former originated with Milne Edwards, and the latter with d'Orbigny. *Centrastræa* is not synonymous with *Astræomorpha*. *Oroseris* is not a perforate coral; and Milne Edwards and Jules Haimes were quite correct in stating that the genus "se rapproche beaucoup des *Comoseris*;" and it is incorrect to state that one genus really bears but a faint resemblance to the other. *Oroseris* is a subgenus of *Comoseris*, which is not one of the Perforata.

Microsolena, Lmx., is one of the Fungida.

Cyathophyllia, E. de From., is posterior in date to *Antillia*, Dunc., and therefore *C. oolitica*, Tomes, is *Antillia oolitica*, Tomes, sp.; but as *Antillia* is a subgenus of *Circophyllia*, Edw. & H., the name should be *Circophyllia oolitica*, Tomes, sp.

What is termed the "rejuvenescence" of corals by some zoophytologists has been long recognized as irregularity of growth, and there should be no difficulty in distinguishing worn growth-rings from calicular gemmation; but this has been confounded with the other condition. *Oppelismilia*, Dunc., is retained as a subgenus of *Montlivaltia*. *Axosmilia Wrighti*, Edw. & H., and *Montlivaltia Holli* (*Oppelismilia*, Dunc.), are not identical, they are both simple corals and differ from the fasciculate and compound genus *Donacosmilia*, E. de From. *Epismilia* is a worthless genus, because one can never be certain that the septa were not once spinose; moreover, the presence and absence of spines and dentations on the free edges of the septa are not of physiological importance, and there is no distinction to be made between the soft parts of the recent corals with and without ragged septa. *Clausastræa consobrina*, Edw. & H., is not a species of *Confusastræa*. *Isastræa tenuistriata*, M'Coy, sp., confounded with some other form, but not by its author, is a true Isastrean. *Confusastræa tenuistriata*, Tomes, cannot remain in the genus, for it has characters which do not belong to it. *Chorisastræa*, de From., is not a good genus according to Milne Edwards and Jules Haime, Reuss and Stoliczka; it makes a method of growth which is common to several fossil and recent genera of primary importance. *Thecosmilia gregaria* and *T. obtusa* are names which should be retained, and the forms should be removed from *Chorisastræa*. *Heterogyra*, Reuss, is a good genus. *Symphyllia Etheridgii*, Dunc., belongs to the genus with which it is associated, and not to *Phyllogyra*, Tomes. *Thecoseris* is an epitheoate *Leptophyllia*, and *T. polymorpha*, Tomes, is quite distinct in its morphology from *Turbinoseris* and *Palæoseris*, Dunc. *Cryptocœnia*, d'Orb., is an imperfectly distinguished genus, and is replaced by *Cyathophora*, Edw. & H. Therefore *Cyathophora tuberosa*, Dunc., which has not a close resemblance with *C. Luciensis*, Edw. & H., and also *C. Pratti*, Edw. & H., remain as good species of their genus. The septal arrangement of what is termed *Cryptocœnia microphylla*, Tomes, is incorrectly given. *Montlivaltia caryophyllata*, Edw. & H., had not its septa wrongly described by its illustrious authors; Mr. Tomes says that they made an obvious mistake, and his own accusation proves that they were correct. The subject of fissiparity was not originally introduced by M. de Fromentel, but was well understood at the time when he wrote. The walls are not defective in corals increasing fissiparously. Fissiparity and gemmation were not confounded by Milne Edwards and J. Haime or by the author. *Thecosmilia Slatteri*, Tomes, is a variety of *Cladophyllia Babeana*. The figure given by the author of *Thamnastræa Waltoni*, Edw. and H., has been misapprehended.

Isastræa oblonga, Edw. & H., was correctly described by those authors, and no addition to our knowledge of the form has been made. The genus *Isastræa* has its species budding within the calice and close to the outer wall, never, as stated, between the walls of calices. *Heliocœnia* is a subgenus of *Stylina*, and differs from *Placocœnia*, d'Orb. *Isastræa Conybearii*, Edw. & H., is a good species;

it is not the same as *Clausastræa* = *Plerastræa Pratti*, Edw. & H. The type specimen of *Plerastræa Pratti*, Edw. & H., has a columella, and the authors of the genus did not describe it as having an essential columella. *Bathycœnia*, Tomes: nothing was stated in the work called "A Revision of the Genera of *Madreporaria*" about the similarity of this genus and *Stylosmilia;* this is a statement difficult of explanation.

Every one of these numerous statements is made in opposition to the opinions of Mr. Tomes. Proper acknowledgment is made regarding the useful knowledge conveyed by Mr. Tomes about the localities of corals and the zones which some frequent.

The author of this communication agrees with Mr. Tomes on two points: Mr. Tomes has shown that, owing to the matrix of *Cyclolytes Lycetti*, Dunc., not being sufficiently removed, the form is his *Dimorphastræa dubia*, and that properly the generic name should be *Dimorpharæa.* Again, Mr. Tomes has raised much doubt in the author's mind where a species is placed by him under the genus *Lepidophyllia*, Dunc., should be placed; probably it will have to come within *Donacosmilia*, as stated by Mr. Tomes; but *Donacosmilia* requires careful working out.

3. "On the *Astrocœniæ* of the Sutton Stone of the Infra-Lias of South Wales." By Prof. P. Martin Duncan, M.B., F.R.S., F.G.S.

The species which were placed in the genus *Astrocœnia*, and which came from the Sutton Stone and Brocastle deposits of the Infra-Lias of South Wales, were re-examined in the instance of *A. gibbosa*, *A. insignis*, *A. parasitica*, and *A. plana* (Dunc.). These species were originally described by the author in his 'Monograph of the British Fossil Corals,' second series, Pal. Soc. 1867, pt. iv. No. 1, and were illustrated. A good specimen of *A. gibbosa* is described, and its structures are shown to be strictly Astrocœnian. The different states of the corallites produced by various conditions, such as growth and gemmation, were explained. The same course was taken with reference to *A. insignis* and *A. parasitica*, and the density of the united walls was shown to have nothing to do with any intermural structure or cœnenchyma in that sense.

A. plana was critically examined, and as it has all the characters of typical *Astrocœniæ*, it remains in that genus with the others.

CORRESPONDENCE.

PALÆONTOLOGICAL NOMENCLATURE.

Sir,—With your permission I wish to present some remarks on the review of certain of my papers which Mr. Lydekker published in the number of the Geological Magazine for October, 1885. The author of the review in question does me the honour to agree with me in my determinations of affinities, but he expresses general disapproval of my systematic methods. While I am much gratified at the agreement in more important matters thus expressed or implied, I think it very desirable that there should be a harmony of action between naturalists in questions of classification and nomenclature. Scientific truth is involved in the former, and convenience in the latter.

In the first place I shall be sustained in differing from Mr. Lydekker whenever he fails to comply with that bulwark of the language of science, the *law of priority*. Except in the matter of the termination of the family name in *idæ*, and its derivation from some genus embraced in it, any name proposed first and accompanied by a definition, must be used in preference to any later name. I take it that this rule applies to all scientific terms whatsoever, which belong to any object, or definite idea abstracted from objects, provided the name be not false in its significance. Hence it will not be proper to yield to mere preferences, as for instance that of Mr. Lydekker, who would rather name orders and suborders from some genus which they contain, when other names have already been proposed in accordance with the rules.

In the application of this rule to the use of names for divisions of higher rank than families, room for the exercise of some discretion may be found. If a name be applied by its author to a group, there are two ways of learning what the proposer of the name had in view or the idea he intends to express; or, in other words, what he would include within its limits. One indication is to be found in his diagnosis; the other in the contents of described objects which he embraces in it. I claim, and I find that custom sanctions the claim, that the name should be retained for the division thus indicated, and for nothing else; and if both diagnosis and content do not represent any natural or tenable division, that the name should be dropped. In insisting on the applicability of diagnosis or content to something real, as the ground of the acceptance of a proposed group and of its name, I of course do not expect completeness in either of the conditions. In fact, these characteristics are *never* to be expected in the early stages of science. But incompleteness is not falsity. An example of a false division with a false diagnosis is to be found in the supposed order of Pachydermata, the name of which is positively rejected, and is not applied to one of those fragments of it which are natural divisions. Another false group is the Theriodonta, which was applied to some South African reptiles of Permian age. The definition, based on the dentition, does not define an order, and is common to more than one family, and the contents of the division agree with the definition. As types with grinding teeth clearly belong to the same order and suborder, there seems to be no place for the name.

To apply these propositions to the cases found in my papers and criticized by Mr. Lydekker. While the Condylarthra do agree generally with the Hyracoidea, the differences are so important, especially in the form of the ungual phalanges, that I cannot refer them to the same suborder at least. Nor am I justified in applying the term Hyracoidea to the two divisions combined, as they certainly must be, for the group Hyracoidea has already a meaning and currency which it is not wise to attempt to disturb. Should I do so, the result would be more complex than that which I have preferred, for not only would the significance of the name Hyracoidea be changed, but I would have to make a new name for the Hyracoidea proper of older authors. The same reasoning applies to the case of the Insectivora. I must either change the significance of the now generally adopted term, or give a new name to the major division of which it forms only a part.

I now come to a second branch of the subject, and that is, the question of the definition of divisions. I lay down the principle, which is, I believe, a generally accepted one, that classification consists of precise definitions; and that the aim of the systematist should be to attain as great precision as the nature of the case will permit. The fact that all definitions which separate adjacent groups will be ultimately found to be fallible, does not permit us to fall into inexact and inconsistent methods of definition. Any absolute difference in the number of parts must be noticed in the system as indices of the steps on the lines of descent. It is only proportions, dimensions, and texture which define species, as represented by their fossil remains. Any system which places animals with four digits in the same genus with others possessing three digits, is inexact. Any system which places animals with four premolar teeth in the same genus with those with three premolars is inexact, unless it can be shown that some species has indifferently three or four premolars. A system which includes animals with a scapholunar bone in the same division with animals with distinct scaphoid and lunar bones, is inexact. I think it will be ultimately agreed that animals with tritubercular superior molars must be more widely separated from those with quadrituberculars, than has hitherto been accepted. Nevertheless I admit that every character loses its value somewhere because of variability. But cases where such are not variable must be carefully distinguished from those where they are.

To again illustrate this point from those brought forward by Mr. Lydekker. My critic "prefers" to arrange the Creodonta with the Carnivora, although they have no scapholunar bone. Now, I ask, what will be the definition of the order Carnivora, if we reject this character? There will be none, as the latter constitutes the only bond of union between its diverse forms. As if an unconscious cerebration opposed this view, Mr. Lydekker maintains the division Creodonta, but gives it a new name, "Carnivora primigenia," a name to which the law of priority opposes an objection. Secondly, on any character at present known the division called Insectivora is heterogeneous, and so soon as exact definitions are demanded, it requires subdivision.[1] In order to distinguish these subdivisions as a whole, with the allied ones, which are clearly neither Edentata, Chiroptera nor Rodentia, I applied to them all, as an order, the name Bunotheria. This group is as definable as any of the others named, and has equal rank. It is the primitive form of placental unguiculate mammal, just as the Taxeopora is the primitive type of primitive ungulate mammal.

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[1] Some of this work remains to be done.

I must now explain my use of the term Ungulata. Lamarck in his Philosophie zoölogique, of which the first edition was published in 1809, distinguished the mammalia into Exongulés, Amphibies, Ongulés, and Onguiculés. Of these, the Ongulés is a natural division which has been adopted by Cuvier, Owen (Odontography) and many other zoölogists, and has been current in zoölogical literature for half a century before it was applied by modern authors to a different and more restricted group (my Diplarthra), in opposition, as I believe, to the law of priority. In fact the distinction of the mammalia into Unguiculata, Ungulata, and Mutica was employed by Linnæus in the twelfth edition of the Systema Naturæ, about a century earlier than the term Ungulata as preferred by Mr. Lydekker.[1] And for placental gyrencephalous mammalia this classification is as natural as any one which has been proposed, and is the only one available for palæontologists. In concluding, I refer to another attempt at change of a long-standing and generally-accepted name by modern authors. I refer to the name Batrachia, which it is sought to replace by the term Amphibia. Although the latter is the better name, it has not the claim of priority by a half century at least. Although the early definitions were imperfect, the contents of the class were then the same as now. The division Batrachia, used by Lamarck and Cuvier, is uniformly employed in the herpetological literature of the last half century, except by a few German authors (*e.g.* Wagler), who combined them with the Reptilia in one division under the name Amphibia. Not only has the name Amphibia no claim on the ground of priority, but the diverse uses to which it has been put also render its use undesirable.

PHILADELPHIA, *Oct.* 30, 1885. E. D. COPE.

OBITUARY.

WALTER FLIGHT, D.SC.(LOND.), F.R.S., &C.

BORN 21ST JANUARY, 1841; DIED 4TH NOVEMBER, 1885.

THE close of this year has witnessed the termination of another bright and promising life, ended all too soon for the hopes and expectations of his many friends.

Walter Flight was the son of William P. Flight, of Winchester, in which city he was born on the 21st January, 1841. He was sent, after a period of pupilage at home, to Queenwood College,

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[1] There is one noteworthy exception to this argument, viz. where Mr. Lydekker remarks that "*Archænodon* appears to us to be a form not improbably connecting the bunodont ungulates like *Elotherium* (with which it has been classed) with the unguiculate mammals," etc. Now this proposition is in opposition to theoretical and actual mammalian phylogeny, as I have remarked in the American Naturalist, 1884, p. 718. It is impossible for any Artiodactyle mammal like *Elotherium* to have direct connection with an unguiculate. The genealogical line must pass backwards through a taxeopod line, and then downward into or through the bunotherian, to complete such a connection.

Hampshire, in the days when George Edmondson was head master, and Tyndall and Debus were the teachers of science.

From Queenwood he went to the University of Halle, where, in the Laboratory of Prof. Heintz, he specially applied himself to chemistry during the winter session of 1863–64.

During 1864 and 1865 he studied at the University of Heidelberg, where, in the Laboratories of the celebrated Professors Bunsen, Kopp, and Kirchhoff, he devoted himself earnestly to acquire that thorough knowledge of the various branches of theoretical and practical chemistry, and that marked facility for overcoming experimental difficulties which characterize the practised and careful worker. From Heidelberg Flight passed to the University of Berlin, where he remained until 1867, studying and working in Prof. Hofmann's Laboratory, and for a time filling the office of his Secretary and Chemical Assistant.

Returning to England in 1867, he graduated D.Sc. in the University of London, and in the following year was appointed by the Senate to the office of Assistant Examiner under Prof. Debus (his former teacher at Queenwood). On the 5th September, 1867, Dr. Flight was appointed an Assistant in the Mineralogical Department of the British Museum, and a Laboratory was fitted up for his use. Here, under the direction of Prof. Maskelyne, the Keeper of Mineralogy, he commenced a series of researches into the chemical composition of the mineral constituents of meteorites and the occluded gases they contained. Many of the methods by which he carried out these investigations were originated by him in the course of his researches, and displayed in a remarkable degree his skill and ingenuity in chemical manipulation.

He was shortly after this date appointed Examiner in Chemistry and Physics at the Royal Military Academy, Woolwich, and in 1876 Examiner to the Royal Military Academy, Cheltenham.

For several years Dr. Flight served on the Luminous Meteors Committee of the British Association, to which he lent much valuable assistance.

Between the years 1864 and 1883 he was author of twenty-one original papers, embracing descriptions of the Cranbourne, Rowton, and Middlesborough Meteorites, which appeared in the Philosophical Transactions; and "A Chapter in the History of Meteorites," which appeared in a succession of twenty-three articles in the GEOLOGICAL MAGAZINE in 1875, 1882, and 1883. He was also joint author or contributor of results to many other papers, chiefly with Professor Story-Maskelyne, F.R.S., on the Mineral Constituents of Meteorites, as the Busti, the Manegaum and the Breitenbach Meteorites, read before the Royal Society between 1870–71.

Dr. Flight was elected to the Royal Society, June 7th, 1883.

In 1884 he was seized by illness which prostrated his mental powers, and rendered it needful for him to resign his appointment in the British Museum in June last, and notwithstanding every care which medical skill or affection of friends could devise, he succumbed on 4th November, leaving a wife and three young children to deplore his early loss.

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